GE Industrial Systems

SPM

SYNCHRONOUS MOTOR PROTECTION AND CONTROL

Instruction Manual

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QMI # 005094

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1.1.1 GENERAL DESCRIPTION

The SPM Synchronous Motor Protection and Control relay controls starting, synchronizing, and protection of collector-ring and brushless type synchronous motors.

The SPM control functions for starting synchronous motors include accurate sensing of motor speed and rotor angle, allowing the unit to apply excitation at optimum speed and angle. This permits closer matching of the motor to the load. Optimum application of excitation also reduces power system disturbance, which occurs when the motor goes through a complete slip cycle with the field energized. In addition, the SPM can take advantage of the extended stall time of a reduced voltage start. It also responds with the proper application of excitation in the event that the motor synchronizes on reluctance torque.

The SPM provides the functions necessary to protect the motor during startup and in the event of asynchronous operation. During startup and restarting, the SPM prevents overheating of the cage winding. To protect against asynchronous operation, the motor power factor is monitored. Two modes of pull-out protection can trip the motor if resynchronization does not occur after a programmed time delay. Motor run time and the number and type of trips are recorded.

The SPM has an optional power factor regulator containing five adjustable setpoints that can be changed while the motor is running for convenient regulator tune-up.

A backlit LCD display and keys allow user configurable setting ranges to meet many applications. The unit comes in a compact S1 drawout case.

The SPM can be applied as part of a complete synchronous motor controller. This consists of four parts. A main device switches the motor on and off the power system. Multifunction digital relays (such as the GE Multilin 469 Motor Management Relay) provide stator protection. DC field protection and control are provided by the SPM. The field contactor and field discharge resistor completes the control assembly.

1.1.2 FUNCTIONAL OVERVIEW

The DC portion of the synchronous motor (rotor assembly) is protected and controlled using a drawout microprocessor based multifunction relay. The relay is adaptable to either collector-ring or brushless type synchronous motors. Protection features include all of the following:

- Cage winding and stall protection during start
- Lockout feature to protect a hot rotor after an incomplete start
- Incomplete sequence trip due to failed acceleration
- Automatic acceleration time adjustment for reduced voltage starting
- Power factor (pull-out) trip with auto resynchronizing feature
- Loss of DC field current trip
- Loss of DC field voltage trip
- Field winding overtemperature trip

After a successful start, the relay automatically applies the DC field to the rotor at a prescribed slip and slip angle to minimize mechanical stresses to the shaft as well as minimizes possible electrical transients to the power system. This is achieved by a dedicated output to close the DC field contactor. The relay is also capable of reluctance torque synchronizing (collector-ring machines only).

A dedicated output is provided in the relay to enable the loading of the motor following the DC field application and unloading of the motor following a trip and/or loss of synchronization (pole slipping).

Control of an SCR type excitation system by means of an analog output to maintain power factor (PF regulation) is available as an option.

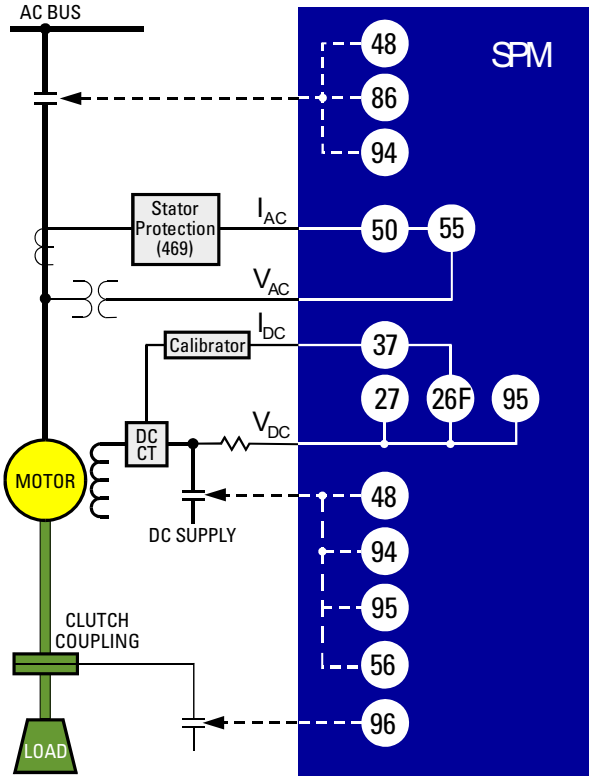
1

The man-machine interface (MMI) consists of a backlit alphanumeric display and a keypad to accommodate relay programming as well as viewing actual motor parameters which comprise:

- AC stator current
- Power factor
- DC field current
- DC field voltage
- DC field resistance
- Running time meter (RTM)

Statistical data includes number and type of trips.

The SPM performs a complete system check prior to starting the motor.



ANSI DEVICE NUMBERS	
26F	Field overtemperature
27	Undervoltage
37	Undercurrent or underpower
48	Incomplete sequence
50	Instantaneous overcurrent
55	Power factor
56	Field application
86	Lock out
94	Tripping
95	Reluctance torque sync. / resync.
96	Autoloading relay

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Figure 1–1: SINGLE LINE DIAGRAM

1.2.1 ORDER CODES

The SPM has all features built into the standard relay and programmable by the user to fit the specific application. The only option in the order code is for Power Factor Regulation. Some of the standard features require an optional external hardware package that must be ordered in addition to the relay itself. These separate packages are explained in the following section.

	SPM – * – *		
Base Unit	SPM	|	|	
Configuration		0	|	Standard starting and protection relay with VDN board
		PF	|	Power Factor regulation option. Used on motors with SCR exciter (not recommended for brushless applications)
Harsh Environment			0	Standard meter
			H	Harsh (chemical) environment conformal coating

1.2.2 ACCESSORIES

- **PG2SPM**: External hardware package for overtemperature and current loss protection up to 200 A (includes 1-DCCT200 and 1-CM)
- **PG4SPM**: External hardware package for overtemperature and current loss protection up to 400 A (includes 1-DCCT400 or DCCT500 and 1-CM)
- **MSPM**: Mounting panel to retrofit existing µSPM cutouts for SPM

1.3.1 TECHNICAL SPECIFICATIONS

PHASE CURRENT INPUTS

CT primary:	5 to 2000 A
CT secondary:	5 A
Conversion range:	0.05 to 6 × CT
Frequency:	50 / 60 Hz
Accuracy:	at < 2 × CT: ±0.5% of 2 × CT true RMS at ≥ 2 × CT: ±1% of 6 × CT true RMS
Current input burden:	<1 VA at 5 A

FIELD CURRENT INPUTS

CT Primary:	5 to 1000 A
Conversion range:	0.05 to 1 × CT
Accuracy:	±2%

EXCITER VOLTAGE INPUTS

Conversion:	0 to 350 V DC (prior to VDN)
Accuracy:	±1%

POWER FACTOR

Range:	0.01 to 1 to –0.01
Time Delay:	0.1 to 10 seconds
Accuracy:	±5%

SWITCH INPUTS (MX AND NX)

Type:	Dry contact

Internal interrogation voltage: 85 to 265 V AC (control voltage)

PF ANALOG OUTPUT

Type:	Active
Output:	0 to 10 V DC max. at RL ≥ 1 KW (min. load)
Accuracy:	±10% (0.1 V)
Isolation:	36 V pk

CONTROL VOLTAGE

Input:	85 to 265 V AC at 48 to 60 Hz
Power:	10 VA nominal
Holdup:	100 ms typical at 120 V AC

RELAY CONTACT

Type:	FAR, TRP: Form A FCX: Form C
Rated load:	10 A AC continuous: NEMA A300 1 A DC continuous: NEMA R300
Break:	10 A at 250 V AC or 30 V DC
Max. operating voltage:	250 V AC

ENVIRONMENT

Humidity:	0 to 95% non-condensing
Operating Temp.:	–20°C to +70°C
Storage Temp.:	–40°C to +85°C

TYPE TESTS

Dielectric Strength:	Per IEC 255-5 and ANSI/IEEE C37.90 2.0 kV for 1 min. from relays, CTs, VTs power supply to Safety Ground
Insulation Resistance:	IEC255-5 500 VDC, from relays, CTs, VTs power supply to Safety Ground
Transients:	ANSI C37.90.1 Oscillatory (2.5kV/1MHz)* ANSI C37.90.1 Fast Rise (5kV/10ns)* Ontario Hydro A-28M-82 IEC255-4 Impulse/High Frequency Disturbance, Class III Level
Impulse Test:	IEC 255-5 0.5J 5kV
EMI:	C37.90.2 Electromagnetic Interference at 150 MHz and 450 MHz, 10V/m
Static:	IEC801-2 Static Discharge
Vibration:	Sinusoidal Vibration 8.0g for 72 hrs.

* With the use of an isolation transformer. Please contact GE Multilin technical support for recommended products.

CERTIFICATION

UL:	UL listed for the USA and Canada

PHYSICAL

Shipping Box:	12.50" × 10.50" × 9.75" (L × H × D) 318 mm × 267 mm × 248 mm (L × H × D)
Ship Weight:	14.25 lb. / 6.45 kg

NOTE

It is recommended that the SPM be powered up at least once per year to prevent deterioration of electrolytic capacitors in the power supply.

Specifications are subject to change without notice.

2.1.1 DESCRIPTION

The SPM can be incorporated in synchronous motor control equipment as a complete controller (including an AC power-switching device for the motor starter) or as a field panel (AC power switching supplied by other device).

2.1.2 ELEMENTS OF A SYNCHRONOUS MOTOR CONTROLLER

A complete synchronous-motor controller has the ability to switch the motor on to and off of the power system and protect the motor from damage that can occur if the motor is running in an abnormal condition such as out-of-synchronization.

A complete synchronous-motor controller consists of a motor starter and switching device (typically a contactor) which controls the main power to the motor. In addition, protective relaying is provided for both the stator and the rotor (such as a 469/SPM combination). Controls for starting and stopping the motor (start-stop push-buttons) are also included. Indicating and metering devices such as line ammeters are supplied if not included in the relays. All of these features are common with motor controllers of all types.

Figure 2–1: EXPLODED VIEW OF THE SPM

2.2.1 UNPACKING THE SPM

When the SPM is shipped separately, carefully unpack the module and report any observable damage or missing components to the carrier and to GE Multilin. All included parts are shown in Figure 2–1: EXPLODED VIEW OF THE SPM on page 2–1.

2.2.2 REMOVING THE DRAWOUT RELAY

1. Remove the faceplate assembly carefully by pushing in on the quick release tabs on the front of the SPM and pulling the faceplate assembly forward. Once the faceplate has pivoted forward, gently lower the faceplate so that it clears the tabs on the bottom of the frame.

NOTE

DO NOT let the faceplate assembly dangle from the connecting wires.

2. Carefully disconnect the ribbon cable from the cradle assembly.
3. Remove the paddle and open the top and bottom locking tabs. The relay can now be removed from the case.

2.2.3 INSERTING THE DRAWOUT RELAY

1. Slide the relay into the case and close the top and bottom locking tabs.
2. Insert the paddle into the opening at the bottom of the relay.
3. Carefully re-connect the ribbon cable to the cradle assembly.

NOTE

DO NOT shift or skew the ribbon connector.

4. Re-mount the faceplate assembly to the case from the front panel. Slide the faceplate onto the tabs on the bottom of the frame and then pivot it up into position over the quick release tabs. The faceplate should gently snap into place.

2.2.4 MOUNTING THE SPM

Mounting the SPM requires careful attention to the following instructions.

CAUTION

DE-ENERGIZE ALL EXISTING EQUIPMENT BEFORE INSTALLING NEW EQUIPMENT.

1. Remove the relay from the case.
2. Prepare the mounting hole in the panel to dimensions shown in Figure 2–2: PHYSICAL DIMENSIONS.
3. Slide the case into the panel from the front.
4. Install the four mounting screws from the rear of the panel. The case is now securely mounted and ready for panel wiring.

2.2.5 SPM MOUNTING ACCESSORIES

See Chapter 8: ACCESSORIES for physical dimensions and mounting requirements.

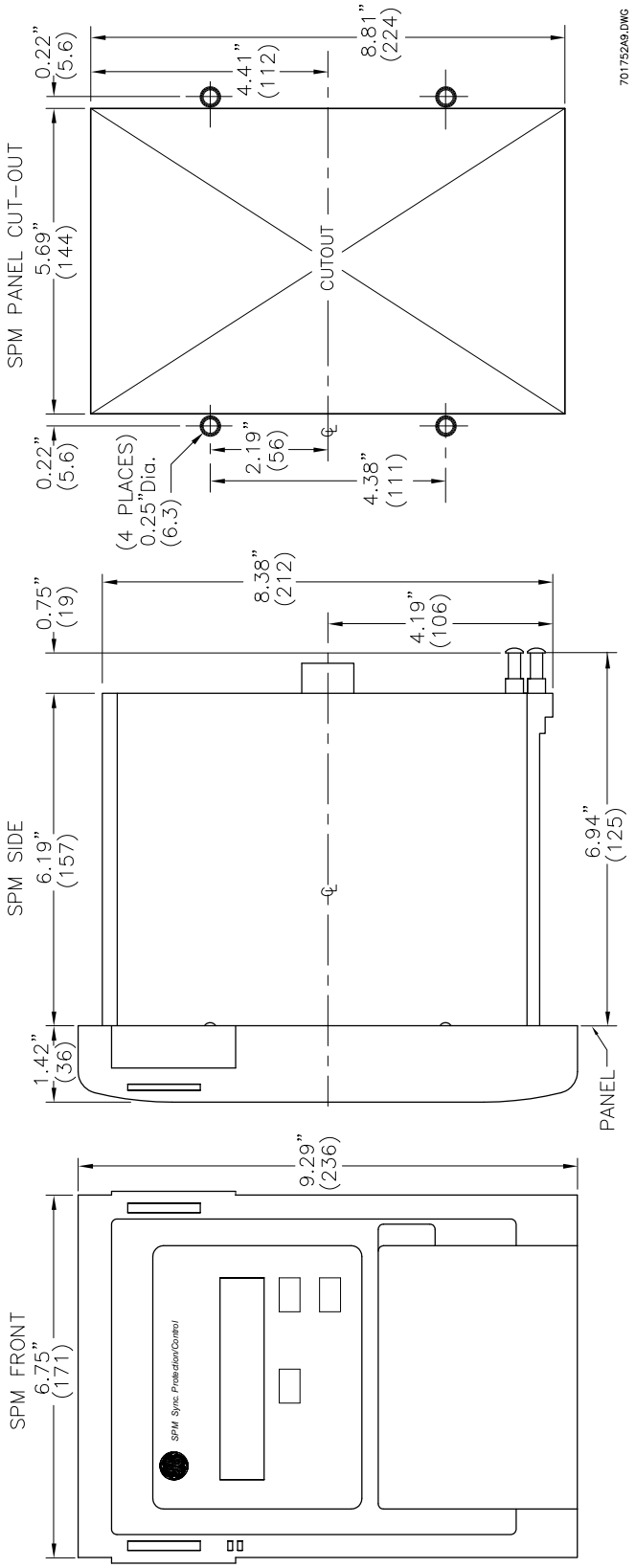


Figure 2–2: PHYSICAL DIMENSIONS

2.3.1 DESCRIPTION

Wire the SPM using one of the following wiring diagrams (one each for brushless, collector ring, and brushless and collector ring). Pay particular attention to the CT and PT inputs. These inputs must be connected as shown below for proper power factor protection.

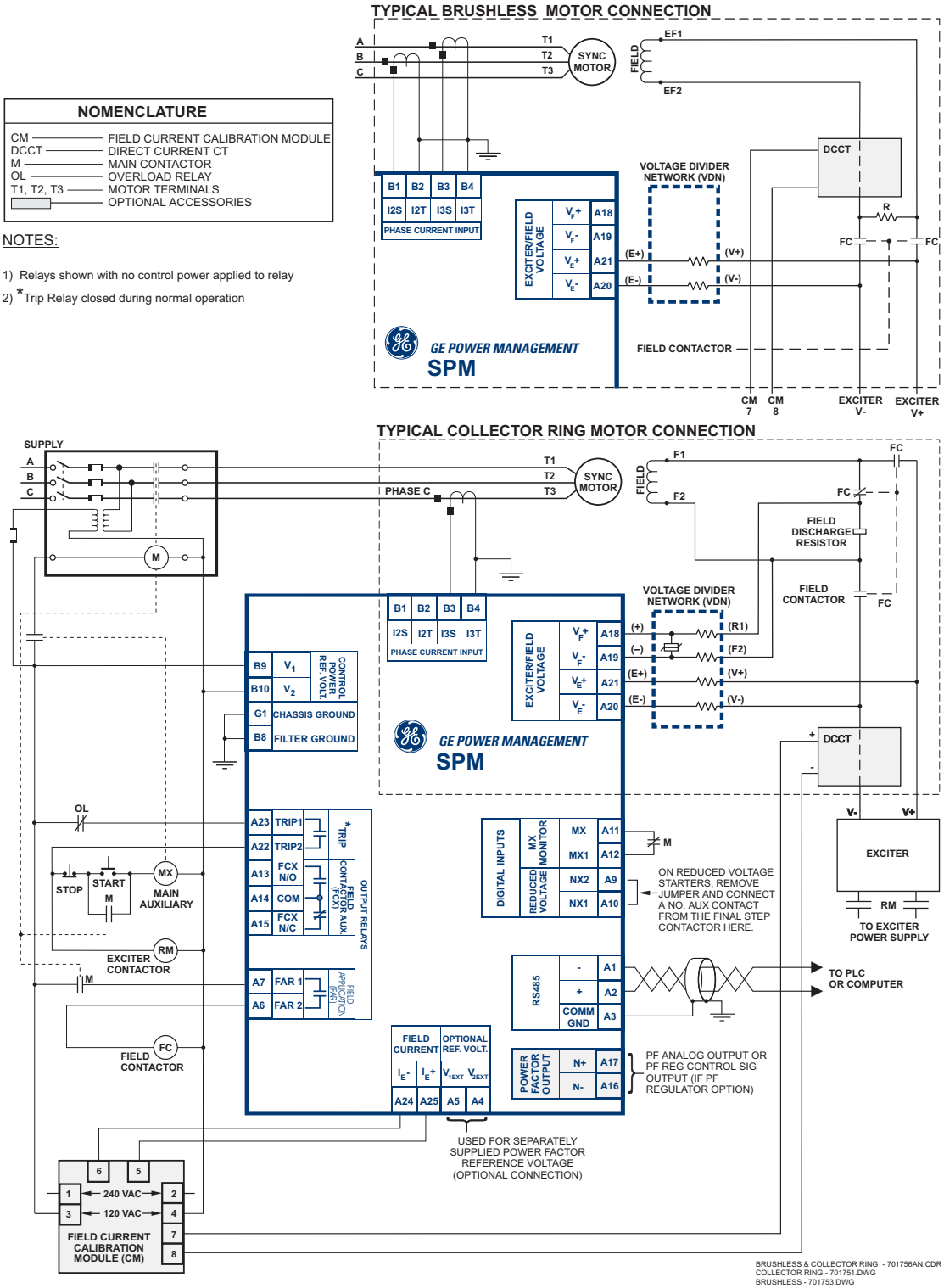
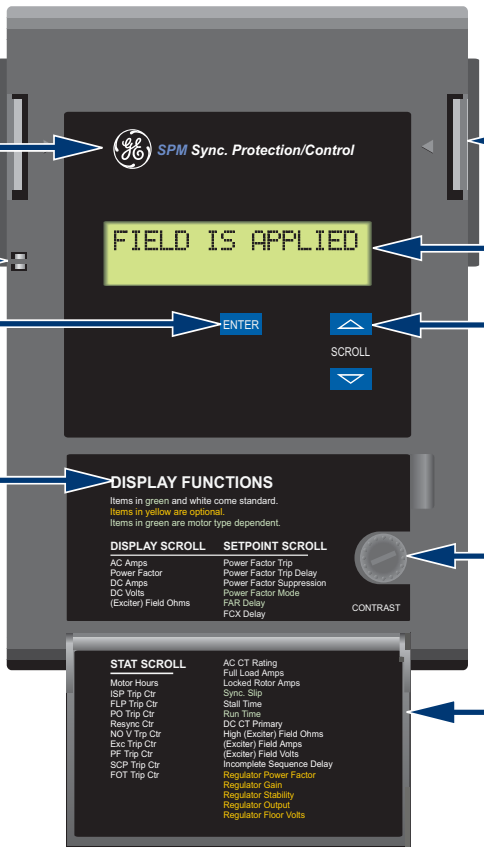


Figure 2–3: TYPICAL WIRING DIAGRAM

FRONT VIEW



GE KEY
Used to enter or exit the different modes of the SPM. These are Standby, Test, Statistics and Programming modes.

LOCKING PROVISION
A wire lead seal can be used to prevent unauthorized removal of relay.

ENTER KEY
Used to make a selection or acts as an enter key.

DISPLAY FUNCTION MENU
Menu of all accessible setpoints and actual values for easy reference.

QUICK RELEASE TABS
Used to remove display for easy access to drawout.

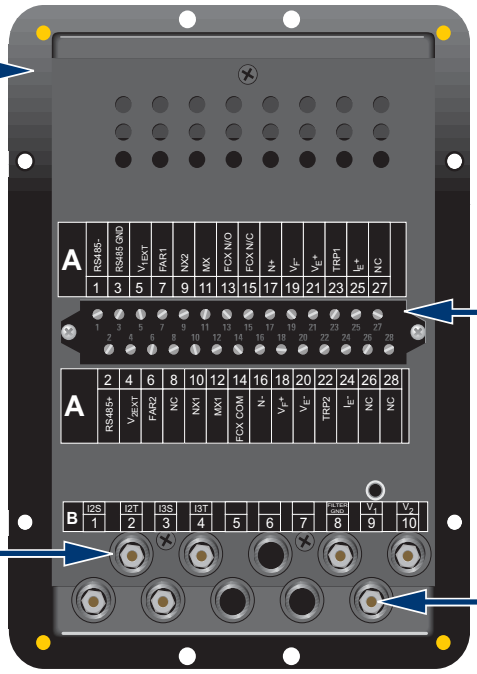
LCD DISPLAY
Back lit 32 character display for setpoints, actual values and status. Programmable auto scan sequence for unattended operation.

SCROLL KEYS
Used to scroll through the various menus and change setpoint parameter values.

CONTRAST DIAL
Lightens or darkens display.

PULLDOWN DOOR
Hides menu when not in use.

REAR VIEW



S1 CASE
Compact S1 rugged metal/bakelite case. Fits standard cutout.

TERMINAL BLOCK A

RELAYS TRIP: Normally open, failsafe trip relay.
FAR: Field application relay.
FCX: Autoloading of the motor.

INPUTS EXCITER: Exciter voltage inputs. Connected via DCCT and CM.
FIELD: DC field voltage input.
REDUCED VOLTAGE: Contact input for reduced voltage starting. Motor "ON" input.
Exciter current input.
Power Factor reference voltage (for seperately powered option).

OUTPUTS POWER FACTOR: 0-10VDC analog signal.

MOTOR LINE CURRENT
2 Phase current inputs.
Accept #8 wire.

CONTROL POWER
85 to 265VAC.

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Figure 2–4: PANEL AND TERMINAL LAYOUT

2.3.2 GROUNDING

The SPM relay must be solidly grounded to a suitable system ground. Extensive filtering and transient protection has been built into the SPM to ensure proper and reliable operation in harsh industrial environments. Proper grounding of the chassis ground terminal is critical to en-sure safety and filtering.

2.3.3 FIELD AND EXCITER VOLTAGE INPUTS

The field voltage inputs (V_F + and V_F –) and exciter voltage inputs (V_E + and V_E –) are connected to the relay via the supplied voltage divider network (VDN).

CAUTION

DO NOT ATTEMPT TO START THE MOTOR WITHOUT THE EXTERNAL RESISTOR ASSEMBLY WIRED. SEVERE DAMAGE TO THE SPM MAY RESULT IF THE EXTERNAL RESISTOR ASSEMBLY IS NOT PROPERLY CONNECTED.

2.3.4 RELAY OUTPUTS

The following is a description of the relay outputs.

1. TRIP: Trip Relay. This relay is normally energized and drops out on loss of power or when the module senses an abnormal condition.
2. FAR: Field Application Relay. This relay picks up at the proper time to apply DC to the motor field.
3. FCX: Loading Relay. This relay picks up when the motor is fully synchronized and ready to be loaded. It is controlled by the "FCX Delay" programmable setpoint.

2.3.5 CURRENT TRANSFORMER INPUT

The SPM is designed to work from a five ampere (5 A) current transformer (CT) secondary. The current transformer must be connected in the proper motor phase. See Figure 2–3: TYPICAL WIRING DIAGRAM on page 2–4 to determine proper phase. For brushless applications, the SPM requires inputs from two motor phases.

2.3.6 POWER FACTOR OUTPUT

This output is a 0 to 10 V DC signal that corresponds linearly to phase shift, and sinusoidal to motor power factor. 0 V is zero lagging power factor, 5 V is unity power factor, and 10 V is zero leading power factor.

Calibration: 1 volt change corresponds to an 18° phase shift (not available with power factor regulation). Do not connect less than 1000 Ω to this output.

2.3.7 DC FIELD CURRENT INPUT

DC field input must be sensed from a separately purchased DCCT (Direct Current, Current Transformer) and CM (Calibration Module).

2.3.8 EXCITER VOLTAGE OUTPUT MONITOR

The output of the field exciter must be connected to the SPM through a separate resistor when exciter voltage failure protection and/or exciter voltage display is required.

2.3.9 POWER FACTOR REGULATION OUTPUT

This optional output replaces the power factor analog signal output. It consists of a 0 to 10 V DC control signal which is used to control an SCR Variable Exciter output to obtain motor power factor regulation.

2.3.10 CONTROL VOLTAGE

If control voltage excursions occur outside the range of 85 to 265 V AC, a provision is available that will allow the user to connect an external stabilizing transformer for operation with severe control power voltage dips. The SPM has separate inputs for control power and power factor reference voltage. This allows connection for control power from a stabilized voltage source of 115 V AC or 230 V AC. Terminal points "V_{1EXT}" and "V_{2EXT}" have been added to accommodate the separate PF reference voltage.

2.3.11 EXTERNAL VOLTAGE PF REFERENCE

When terminal points "V_{1EXT}" and "V_{2EXT}" are used to accommodate a separate PF reference voltage, as described above, a standard protective function will alert the user should this external voltage drop below the acceptable limits for the SPM power supply. This protection will not allow the motor to start while the external voltage is missing, but the SPM will not require a reset before the motor can be restarted. If the external reference voltage is lost while the motor is running, the SPM will trip the motor and will require a reset before the motor can be restarted. "MISSING VOLTAGE!" will be displayed until reset.

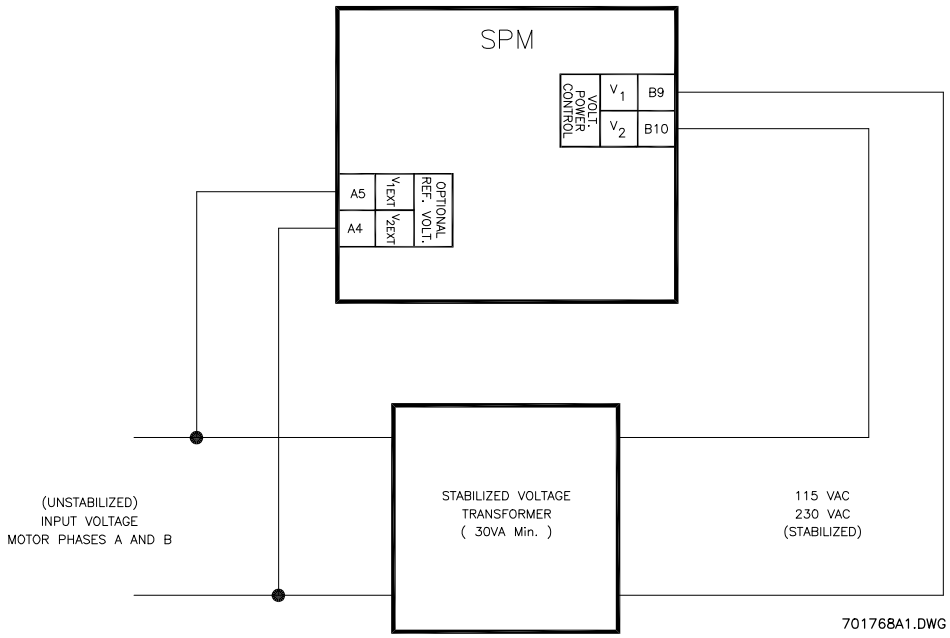


Figure 2–5: REFERENCE VOLTAGE INPUT CONNECTIONS

2.3.12 RS485 COMMUNICATIONS PORT

One two-wire RS485 port is provided. Up to 32 SPMs can be daisy-chained together on a communication channel without exceeding the driver capability. For larger systems, additional serial channels must be added. It is also possible to use commercially available repeaters to increase the number of relays on a single channel to more than 32. Suitable cable should have characteristic impedance of 120 Ω (e.g. Belden #9841) and total wire length should not exceed 4000 ft. Commercially available repeaters will allow for transmission distances greater than 4000 ft.

Voltage differences between remote ends of the communication link are not uncommon. For this reason, surge protection devices are internally installed across all RS485 terminals. Internally an isolated power supply is used to prevent noise coupling. To ensure that all devices in a daisy-chain are at the same potential, it is imperative that the common terminals of each RS485 port are tied together and grounded only once, at the master. Failure to do so may result in intermittent or failed communications. The source computer/PLC/SCADA system should have similar transient protection devices installed, either internally or externally, to ensure maximum reliability. To avoid ground loops, ground the shield at one point only as shown below.

Correct polarity is also essential. SPMs must be wired with all '+' terminals connected together, and all '–' terminals connected together. Each relay must be daisy-chained to the next one. Avoid star or stub connected configurations. The last device at each end of the daisy chain should be terminated with a 120 Ω, ¼ watt resistor in series with a 1 nF capacitor across the '+' and '–' terminals. Observing these guidelines will result in a reliable communication system immune to system transients.

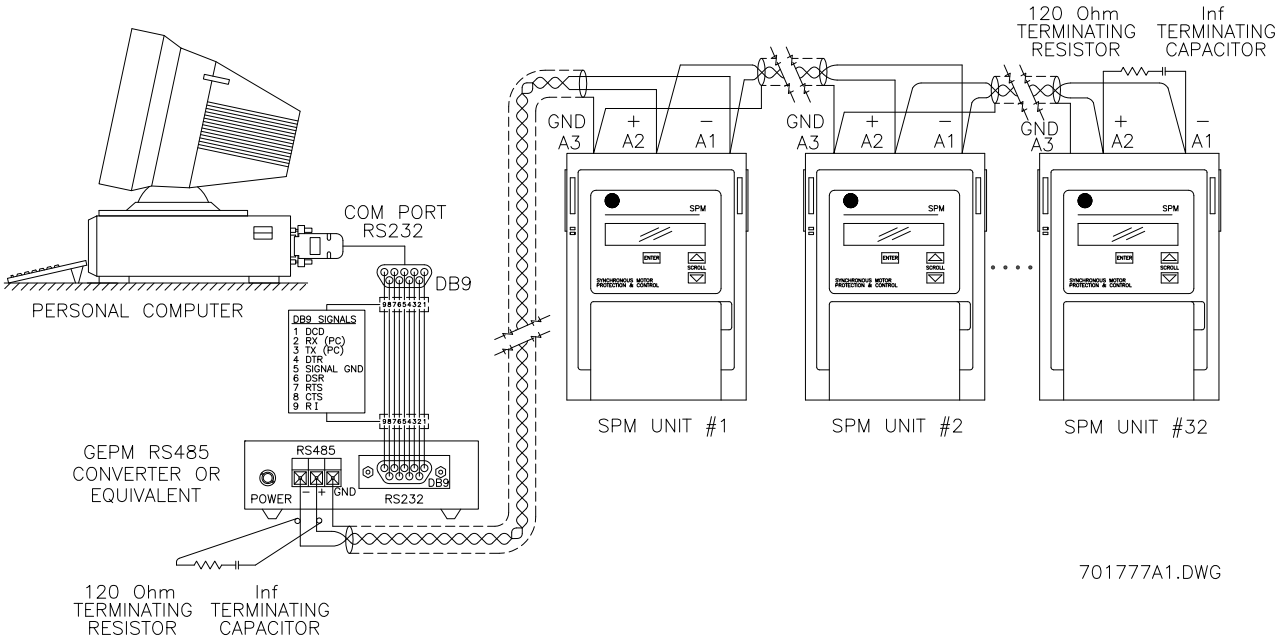


Figure 2–6: RS485 WIRING

3.1.1 GENERAL

The most attractive and widely applied method of starting a synchronous motor is to utilize squirrel cage windings in the pole faces of the synchronous motor rotor. The presence of these windings allows for a reaction (or acceleration) torque to be developed in the rotor as the AC excited stator windings induce current into the squirrel cage windings. Thus, the synchronous motor starts as an induction motor. These rotor windings are frequently referred to as damper or amortisseur windings. The other major function of these windings is to dampen power angle oscillations after the motor has synchronized. Unlike induction motors, no continuous squirrel cage torque is developed at normal running speeds. Examine the figure below:

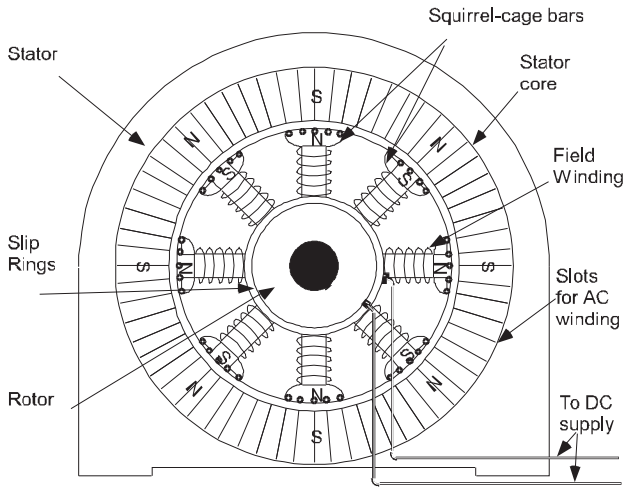


Figure 3–1: SALIENT POLE SYNCHRONOUS MOTOR

When the motor accelerates to near synchronizing speed (about 95% synchronous speed), DC current is introduced into the rotor field windings. This current creates constant polarity poles in the rotor, causing the motor to operate at synchronous speed as the rotor poles "lock" onto the rotating AC stator poles.

Torque at synchronous speed is derived from the magnetic field produced by the DC field coils on the rotor linking the rotating field produced by the AC currents in the armature windings on the stator.

Magnetic polarization of the rotor iron is due to the rotor's physical shape and arrangement and the constant potential DC in coils looped around the circumference of the rotor.

Synchronous motors possess two general categories of torque characteristics. One characteristic is determined by the squirrel-cage design, which produces a torque in relation to "slip" (some speed other than synchronous speed). The other characteristic is determined by the flux in the salient field poles on the rotor as it runs at synchronous speed. The first characteristic is referred to as *starting torque*, while the second characteristic is usually referred to as *synchronous torque*.

In starting mode, the synchronous motor salient poles are not excited by their external DC source. Attempting to start the motor with DC applied to the field does not allow the motor to accelerate. In addition, there is a very large oscillating torque component at slip frequency, produced by field excitation, which could result in motor damage if full field current is applied during the entire starting sequence. Therefore, application of DC to the field is usually delayed until the motor reaches a speed where it can be pulled into synchronism without slip.

At synchronous speed, the ferro-magnetic rotor poles become magnetized, resulting in a small torque (reluctance torque) which enables the motor to run at very light loads in synchronism without external excitation. Reluctance torque can also pull the motor into step if it is lightly loaded and coupled to low inertia.

It is convenient to make an analogy of a synchronous motor to a current transformer for the purpose of demonstrating angular relationship of field current and flux with rotor position.

If I_1 is an equivalent current in the stator causing the transformer action, then I_1 will be about 180° from I_2 (or I_{FD}), and the flux will be 90° behind I_{FD}. Very significantly, then, the point of maximum-induced flux (Ø) occurs as the induced field current I_{FD} passes through zero from negative to positive; maximum rate of change of current. See the figure below.

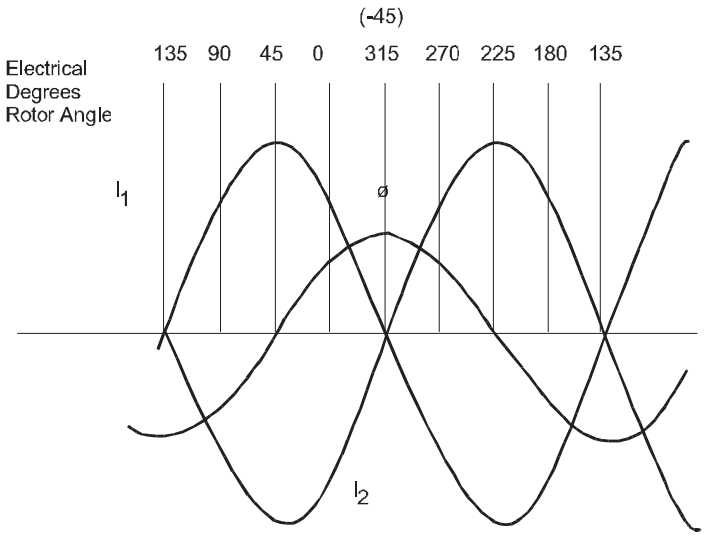


Figure 3–2: TYPICAL TRANSFORMER ROTOR FLUX AND CURRENT (CONSTANT SLIP)

The rotor angle at which I_1 and I_2 go through zero depends upon the reactance-to-resistance ratio in the field circuit. A very high value of reactance-to-resistance shifts the angle toward –90°. Reactance is high at low speed (high frequency). At high speed (low slip, low frequency), reactance decreases and the angle shifts toward 0° if the circuit includes a high value of resistance. As the stator goes beyond –45°, the torque increases (due to increased stator flux). At this point, I_{FD} yields a convenient indicator of maximum flux and increasing torque from which excitation is applied for maximum effectiveness.

If the field discharge loop is opened at the point of maximum flux, this flux is "trapped." Applying external excitation in correct polarity to increase this trapped flux at this instant makes maximum use of its existence. At this point the stator pole has just moved by and is in position to pull the rotor forward into synchronous alignment. See the figure below.

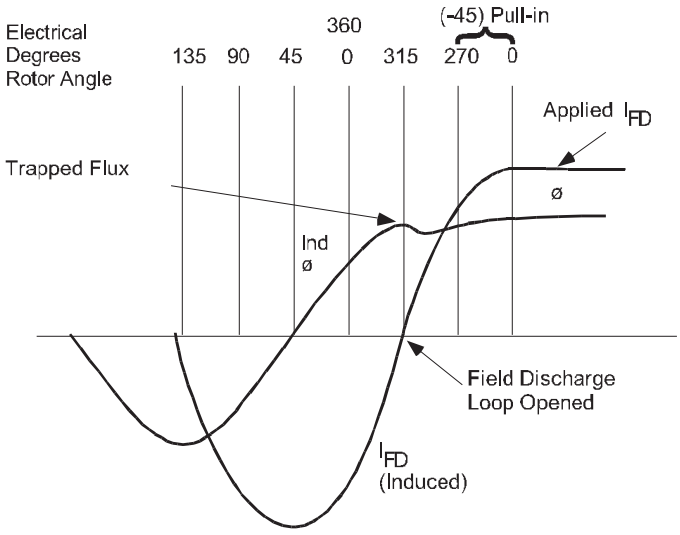
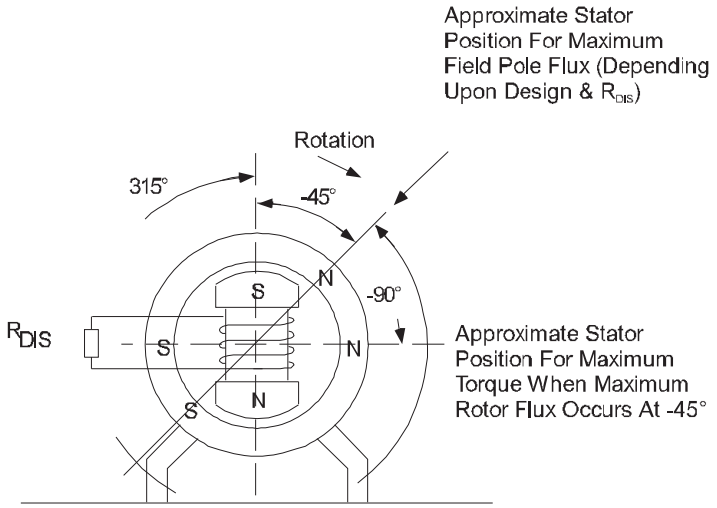


Figure 3–3: TYPICAL ROTOR FLUX AND CURRENT AT PULL-IN



Note: Angular displacement of rotor with respect to stator is given a negative sign to indicate the motoring condition.

Figure 3–4: ANGULAR DISPLACEMENT OF ROTOR

It has been established that salient-pole torque near synchronous speed is a function of both slip and field-discharge resistance. The combined effects of cage torque and salient pole torque for a typical motor are shown below. The effect of a higher value of discharge resistance on a medium-torque motor are shown in Figure 3–6: FIELD DISCHARGE RESISTANCE – MEDIUM STARTING TORQUE. Obviously, without salient-pole torque the motor would cease to accelerate certain loads at some point on the speed axis.

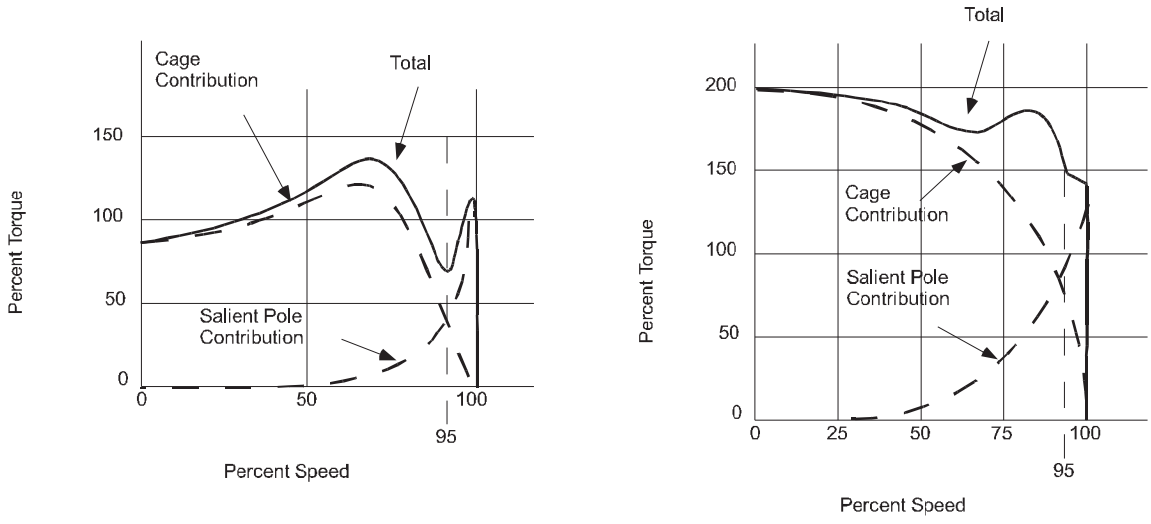


Figure 3–5: MOTOR TORQUE VS. SPEED

The upper limit of the discharge resistance is governed by the other function of the resistor, which is reducing field voltage to safe levels during starting. As the discharge resistance increases so does the induced voltage, and at some point this voltage would be damaging to insulation or other components in the field circuit. Solid-state excitation and control components in the field circuit have had the effect of making the discharge resistance and its voltage effect more significant. There is a greater sensitivity to field voltage tolerance levels with solid-state components.

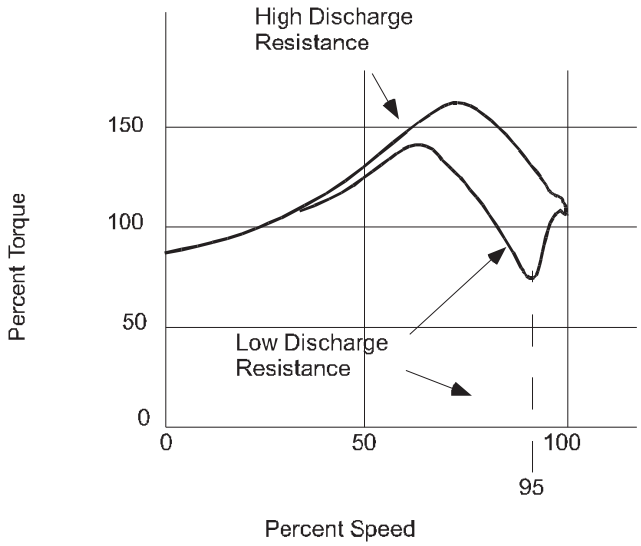


Figure 3–6: FIELD DISCHARGE RESISTANCE – MEDIUM STARTING TORQUE

Selection of the value of the field discharge resistance is a decision that may require judicious application of several factors present on a particular drive, such as torque, excitation systems, and control components.

The importance of speed for applying field cannot be over-emphasized. Rotor and load masses cannot be accelerated fast enough to allow synchronization, if slip is in excess of ten percent.

Synchronous-motor controllers which can accurately apply field at an optimum speed and a favorable angle permit matching the motor to the load with a greater degree of precision than might otherwise be possible. The increase in load which can be pulled in due to precision application of field will vary from one motor design to another along with system inertia.

Applying excitation at the point of zero induced current (favorable angle) takes advantage of motor capability in two ways:

1. It catches (“traps”) salient-pole flux at significant magnitude (provided there is a field discharge resistor of adequate value) and uses it for torque during a 180° acceleration period.
2. It catches the rotor in correct angular position to be pulled forward into step.

In addition to permitting closer matching of motor to load, optimum application of excitation also reduces power system disturbance which occurs when the motor goes through a complete slip cycle with the field energized. If the motor is large relative to the power system, surges transmitted to the system will be at a minimum if field is applied to prevent slip at pull-in.

3.2.1 STARTING AND SYNCHRONIZING

Control functions for starting the synchronous motor include the following:

- Applying power to the stator; at full voltage or reduced voltage.
- Shunting the field with a discharge resistor (FDRS).
- Sensing rotor speed.
- Sensing rotor angle.
- Applying excitation at optimum speed and angle.
- Reluctance torque synchronizing.

The first step in starting a synchronous motor is to apply power to the stator by means of a magnetic contactor or circuit breaker.

Shunting a resistor around the motor field during starting is accomplished with a field contactor. Optimum application of excitation (that is, closing the field contactor) requires accurate sensing of motor speed and rotor angle. This SPM provides this function. Optimum speed for pull-in varies with motor design and with the field discharge resistor value. Adjustment of the control to apply field at various values of motor speed is important. The correct rotor angle for field application does not vary and is always the point where induced field current passes through zero going from negative to positive – the point of maximum rotor flux (see Figure 3–3:: TYPICAL ROTOR FLUX AND CURRENT AT PULL-IN on page 3–2). Maximum utilization of motor pull-in capability depends upon the degree to which the control can accurately sense speed and rotor angle.

Rotor frequency is the most positive electrical parameter available for indicating speed, and can be sensed by detecting the frequency of the voltage across FDRS. Voltage across FDRS is not actually "induced field voltage," but is the voltage which is essentially in time phase relation to the current through the resistor. That is, the current goes through zero at the same time the voltage goes through zero.

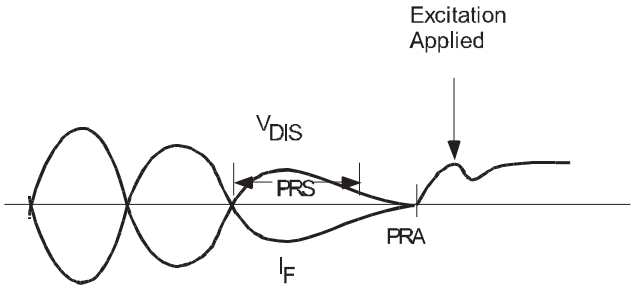
The SPM detects the proper rotor speed (PRS) and rotor angle (PRA) signal, implemented in the Field Programmable Gate Array (FPGA). Outputs from the PRS and the circuits are used to determine the proper time to close the Field Application Relay (FAR), based on the percent synchronous slip setpoint. When the proper rotor speed and the proper rotor angle conditions are met as determined by the FPGA, the CPU delivers a signal to the FAR Relay so it can close its contact FAR1-FAR2. FAR picks up field contactor FC to apply excitation to the motor field and to open the field discharge resistor loop. See Figure 2–4: PANEL AND TERMINAL LAYOUT on page 2–5 for details. The speed at which the motor is to synchronize (PRS) can be programmed from 90 to 99.5% of synchronous speed.

3.2.2 RELUCTANCE TORQUE SYNCHRONIZING

A lightly loaded synchronous motor connected to a low inertial load may pull into synchronism before the rotor poles are externally magnetized. This is commonly known as reluctance torque synchronizing. This magnetization can result in sufficient torque to hold the salient poles in direct alignment with corresponding stator poles and run the motor at synchronous speed. However, when load is applied, the rotor begins to slip since the torque developed is only a fraction of rated torque under separate excitation. Furthermore, the rotor is polarized by the stator flux under this condition and can therefore be polarized in any direct axis alignment; occurring each 180°. External excitation forces pole-to-pole alignment in only one orientation of the direct axis.

Should the rotor pull in to synchronism 180° away from the normal running alignment, external excitation will build up rotor flux in opposition to the stator flux. As the external excitation builds up, correct alignment of rotor to stator occurs by slipping one pole and the motor will then run in normal synchronism.

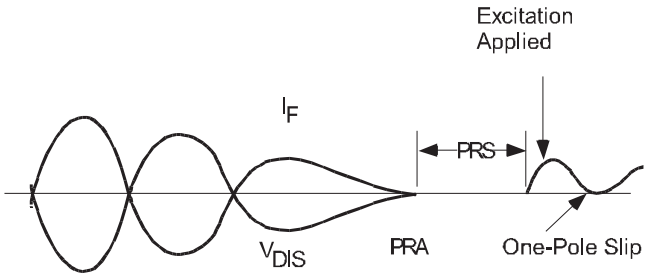
The Field Application Control must respond in such a way as to proceed with proper application of excitation in the event the motor does synchronize on reluctance torque. The following diagram demonstrates how the SPM automatically responds to reluctance torque synchronizing.



CORRECT ORIENTATION

Operation

For correct orientation of the reluctance-torque rotor magnetization, PRS times out first and the PRS flag is set. PRA flag is set when VDIS falls below ±40V. Since both PRA and PRS flags are set simultaneously, the field is applied.



180° DISORIENTATION

Operation

For 180 degree disorientation of the reluctance-torque rotor magnetization, PRA flag is set when VDIS falls within the range of ±40V. At this point, PRS starts timing. When PRS times out, the PRS flag is set. PRA and PRS flags now appear simultaneously, the field is applied.

Figure 3–7: RELUCTANCE TORQUE MOTOR MAGNETIZATION

The amortisseur, or cage winding of a synchronous motor, is probably the element most susceptible to thermal damage. Its function is essentially operative only during starting, and there are limitations on space available for its construction onto the rotor. Hence, it is usually made of lighter material than the cage winding of an induction motor. The cage is also vulnerable to overheating should the motor be allowed to run out of synchronism with no excitation. In this case, it runs as an induction motor at some value of slip which will produce cage current that develops running torque. However, the cage of a synchronous motor is not designed for continuous operation. Therefore, an important protective function of the controller is to prevent overheating of the cage winding both during starting and running out of synchronism.

Monitoring the starting condition of a synchronous motor can be accomplished by looking at the frequency of induced field current, the same procedure used to accomplish synchronizing. Motor designers always place a limit on the time a particular motor can be allowed to remain stalled ("allowable stall time"). An accelerated schedule can then be established for the motor in terms of running time at any speed less than synchronous as a percent of allowable stall time. Increased air circulation from the rotor fan reduces the heating rate as the motor accelerates. Frequency can be measured directly as an indication of speed, and the designer's curves for speed versus time can be used for protection by software that integrates the time-speed function. The figure below shows the typical cage heating protection characteristics during acceleration.

The time-speed function shown in below is determined internally by SPM software. The motor speed is determined from the induced field voltage frequency. The programmed values for maximum allowable stall time and 50% speed run time determine which characteristic of protection is required from the family of curves.

The SPM will cause a TRIP operation and display "SQL CAGE TRIP" if it calculates that the thermal limit of the cage winding is reached. The SPM will also prevent an attempted restart if it calculates, from learned start experience, that the cage winding has not had sufficient cooling time to allow a successful start. In this case the message "START INHIBITED! Ready in xxx min" will be displayed

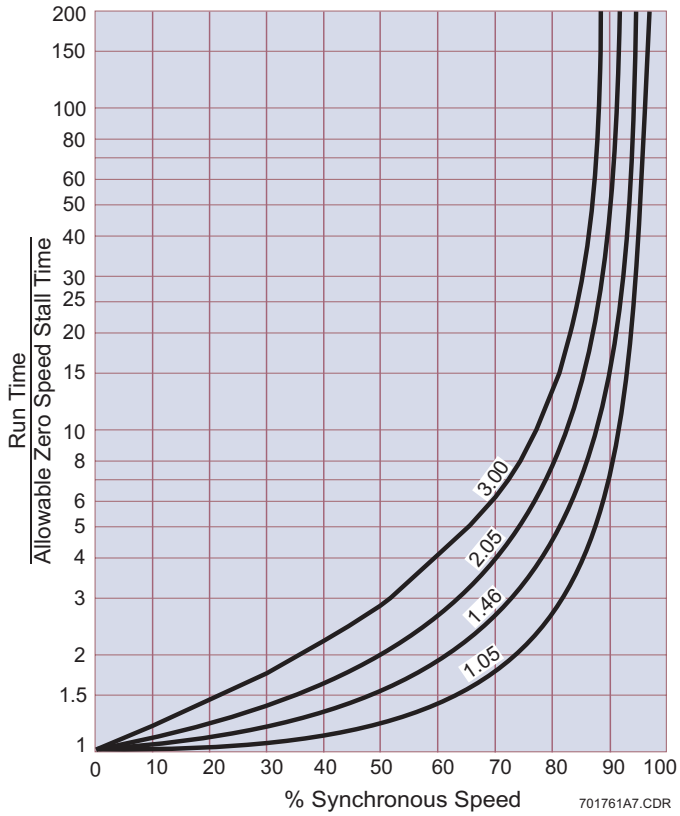


Figure 3–8: AMORTISSEUR WINDING PROTECTION

3.2.4 REDUCED VOLTAGE STARTING

Many synchronous motor starting applications involve either reduced voltage (starting reactor or autotransformer) or part-winding starting methods. When these methods are used, the available torque for acceleration is reduced from the torque that would result from a full-voltage start. Also, the allowable stall time of a motor is extended during a reduced-voltage start due to the reduced heating-rate resulting from lower inrush currents.

The SPM has the ability to take advantage of the motor's extended stall time so that the motor and load can accelerate to synchronous speed in a time period longer than would be allowed with a full voltage start. The acceleration torque is reduced as the square of the ratio of reduced voltage to full voltage, and the motor-heating rate is proportional to the square of the starting current. Since the motor inrush current is reduced proportionally with the voltage reduction (due to the constant impedance of the synchronous motor at stall) the following allowable stall time factor applies:

$$\left(\frac{I_{PLR}}{I_{MLR}}\right)^2$$

where: I_{PLR} = programmed full voltage locked rotor current.
I_{MLR} = measured inrush current.

This ratio can be used as a factor for increasing the stall time above the full voltage allowable stall time for any given speed. See Figure 19.

The SPM calculates the ratio, squares it, and factors this value into the stall time algorithm approximately one-tenth of a second after motor starts. When the final step contactor closes and applies full voltage to the motor windings, a N.O. interlock from this contactor is wired to the SPM to signal that the motor is now at full voltage. The correction factor for reduced voltage starts then immediately becomes unity.

If, for any reason, it is not desirable to have this ratio correction factored in, a jumper may be placed across inputs NX1 and NX2. Conversely, if the motor is started from a weak system, and significant voltage dips are expected during starting, the factory jumper from NX1 to NX2 may be removed. The SPM will automatically extend the stall and accelerating time per the reduced voltage factor.

NOTE

To find the protective characteristic used, plot the programmed value for 50% run time and draw in the complete curve through the plotted point using the above curves as a guide.

NOTE

The curves shown in the following diagram demonstrate how the trip characteristic of the amortisseur winding protection is adjusted for reduced voltage starts. For this example, curve 1 is taken from one of the family of curves in Figure 3–8: AMORTISSEUR WINDING PROTECTION on page 3–7.

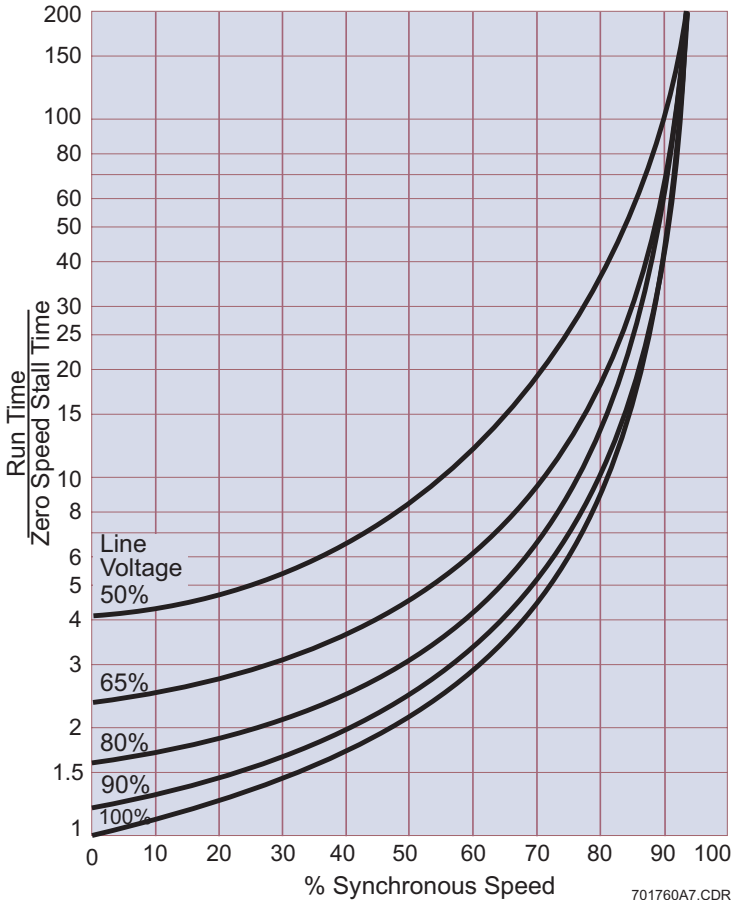


Figure 3–9: PROTECTION FOR REDUCED VOLTAGE STARTS

3.2.5 POWER FACTOR (PULL-OUT) PROTECTION

Synchronous motors are designed to run at constant speed and drive shaft loads from torque derived from the magnetic poles on their rotors magnetically linking opposite stator poles. Whenever the rotor turns at a speed less than that of stator rotating field, the motor is said to be slipping poles. Slip can occur with the field poles magnetized while running in synchronism from the following four major causes.

1. A gradual increase in load beyond the pull-out capabilities of the motor.
2. A slow decrease in field current.
3. A sudden large impact load.
4. A system fault or voltage dip lasting long enough to cause pull-out.

Loss of synchronism with field applied will create intense pulsations in torque at the motor shaft each time a stator pole passes a rotor pole. Corresponding pulsations occur in line current. Both types of pulsations can be damaging. Torque pulsations can break a shaft, coupling, or other mechanical elements, and current pulsations can interfere with smooth power system operation. Slipping poles with field applied is always unacceptable for a synchronous motor, therefore some means must be provided to prevent this condition from occurring.

One of the most reliable indicators of synchronous and asynchronous (out-of-step) operation is the motor power factor. Power factor is related to the phase angle between voltage and current. Synchronous motors seldom, if ever, operate continuously at lagging power factor. Synchronous motors run at either unity or some value of leading power factor. Lagging power factor appears when the motor load angle increases beyond rated, becoming almost fully lagging (90°) as the motor slips out-of-step. Therefore, lagging power factor can be utilized to initiate action to prevent slipping.

Torque and power pulsations during slip can be reduced by removing field current to the rotor poles. The motor will then run essentially as an induction motor on its amortisseur winding. Slip with the field current removed is tolerable to the load and power system but intolerable for any length of time to the motor amortisseur winding itself, since the winding is designed with limited thermal capability and for short-time operation. Motor Power Factor during induction motor operation (that is with field removed) is always lagging. However, the degree to which the current lags the voltage is less than at pull-out when field poles are excited. Lagging power factor can again be utilized as an indicator of "slip" during induction motor operation.

For synchronous motors, power-factor monitoring can be employed to guard against pull-out or loss of field conditions.

3.2.6 POWER FACTOR OPERATION

Motor pull-out protection is provided by a circuit which monitors power factor and has a built-in time delay to prevent inadvertent tripping on transients. The SPM senses power factor by monitoring the voltage across motor Phases One and Two and the current in Phase Three. Figure 20 is a phasor diagram depicting the relationship of voltage and current for various power factors.

The SPM automatically suppresses power factor protection until the programmed setpoint "FCX" times out. The SPM can be programmed to suppress power factor trip action if the line current is less than 6 percent or 50 percent of the rated full load current via the PF Suppression setpoint. Selecting the "Ridethru" mode for the PF Mode setpoint places the SPM into ride-through mode. Selecting the "Re-sync" mode for the PF Mode setpoint places the SPM into resync mode. These modes are described in the next section.

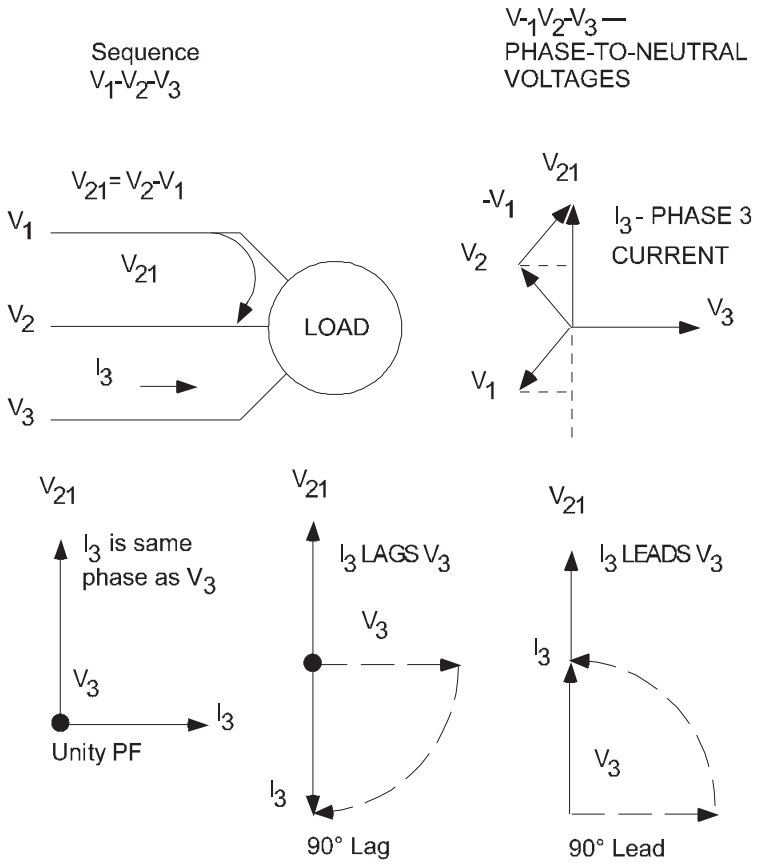


Figure 3–10: POWER FACTOR SENSING EXAMPLE

3.2.7 CONTROLLER ACTION DURING PULL-OUT

If excessive mechanical load is applied to the motor shaft during normal running of the motor in synchronism, the resulting lagging power factor and/or line current surge will be detected by the SPM. Two forms of pull-out protection are available. They are as follows

a) RESYNC MODE

Resync mode operation causes the Field Application Relay, FAR, to remove the motor-field excitation. Action will occur from either lagging power factor below the programmed setpoint or a line current surge above approximately four times motor full-load current.

Relay FCX drops out at the same time as FAR. Load is removed if an automatic loader is connected.

The motor will continue to run with field removed for the programmed power factor delay time, and if resynchronization does not occur within this time, the TRIP relay will operate and the motor will stop.

The display will indicate "FAIL TO RESYNC!"

b) RIDE-THRU MODE

If the alternate "ride-thru" mode is selected, the field is not removed immediately as in the resync mode.

Instead, if the power factor dips below the trip point and persists for the PF time delay, the TRIP relay will operate and the motor will stop. Also, a line current surge greater than approximately four times motor full load will cause TRIP operation if the PF time delay is exceeded. Power factor trips are indicated by "PWR FACTOR TRIP!" in the display. Line current surges greater than four times rated line current are indicated by "PULL-OUT TRIP!".

3.2.8 EFFECT OF VOLTAGE DIPS ON MOTOR POWER FACTOR

Solid-state excitation systems have an effect on the way motor power factor responds to line voltage dips. The effect may be to cause a power-factor relay to operate inadvertently. This causes the motor to trip on lagging power factor caused by a transient condition which is not an actual pull-out condition.

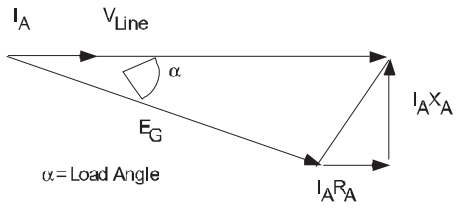
A solid-state exciter differs from a rotating exciter in the way it responds to voltage dips. The rotating inertia of a Motor-Generator set may maintain excitation voltage relatively constant for several seconds, but a solid-state exciter has practically no built-in delay in the way it responds to line voltage. Therefore, any delay in change of motor-rotor flux following an excitation voltage change is determined by the time constant of the rotor field poles themselves. This is usually 0.5 to 1.0 seconds.

The sequence of events transpiring during a voltage dip with a solid-state exciter is shown in Figure 3–11: POWER FACTOR RESPONSE TO LINE VARIANCE on page 3–14.

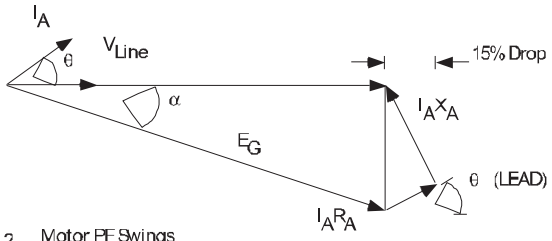
Assuming the condition of a line voltage decrease of 15% with the motor initially at unity power factor, the power factor will swing leading momentarily because the generated EMF does not change until the rotor flux decreases (determined by field time constant). The motor will tend to maintain constant horsepower by slightly increasing line current. As the field flux decreases, generated EMF also decreases, and the power factor will move back towards unity, and there will be a load angle increase to permit motor torque to be restored to that required to drive the load. During both of these sequences the motor power factor has not become significantly lagging, so the power-factor relay does not operate.

Finally, when line voltage comes back to normal, the power factor will momentarily swing over to lagging and the power factor protection relay will trip because the rotor flux does not respond as rapidly to change as the stator. The generated EMF is low relative to line volts for a time period long enough to operate the relay.

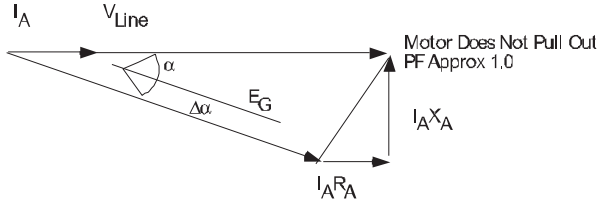
A power-factor device with a 1.0 second built-in time delay should remain unaffected by these changes.



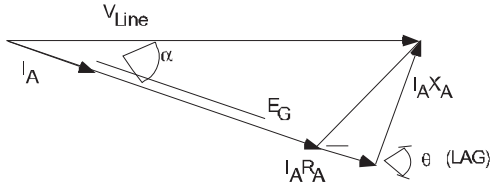
1 Motor at Unity PF
Normal Load I_AR_A
Parallel with Line Volts



2 Motor PF Swings
Leading When Line Voltage
Drops and Excitation Remains
Constant (Due to Field Time Constant)



3 Motor PF Becomes Slightly Lagging
When Excitation Drop Equals Line Drop



4 Motor PF Dips Heavily Lagging
When Line Voltage is Restored

E_G = Generated EMF
I_A = Line Amperes
R_A = Armature Resistance
X_A = Arm Reactance

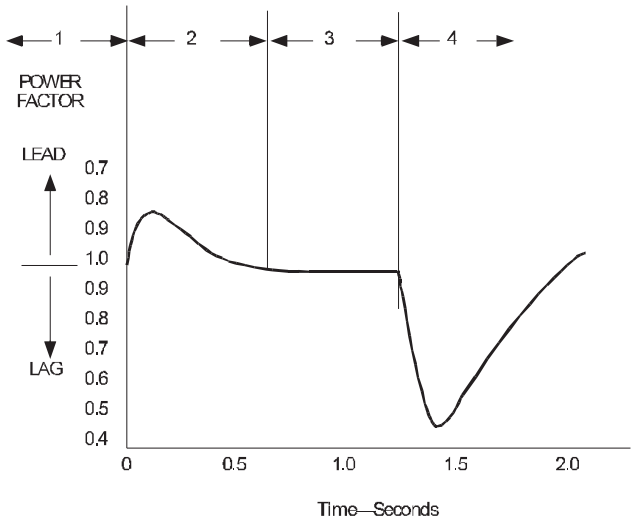


Figure 3–11: POWER FACTOR RESPONSE TO LINE VARIANCE

3.2.9 POWER FACTOR DETECTION & INDICATION – OVERHAULING LOAD

Many synchronous motor applications require that the motor operate with an overhauling load (in generating mode). The power factor protection must be able to provide pull-out protection during overhauling load conditions.

The SPM provides pull-out protection for the synchronous motor operating in both the generating and the motoring mode. However, conventional power factor detection and indication for motors and generators are opposite. Simply, the convention is that a motor has a leading power factor when it is overexcited (producing reactive power). A generator, by convention, is leading power factor when it is underexcited (consuming reactive power). In order to understand this difference, it is necessary to recognize that the definition of a motor voltage reference phasor is 180° displaced from its corresponding conventional generator voltage reference phasor.

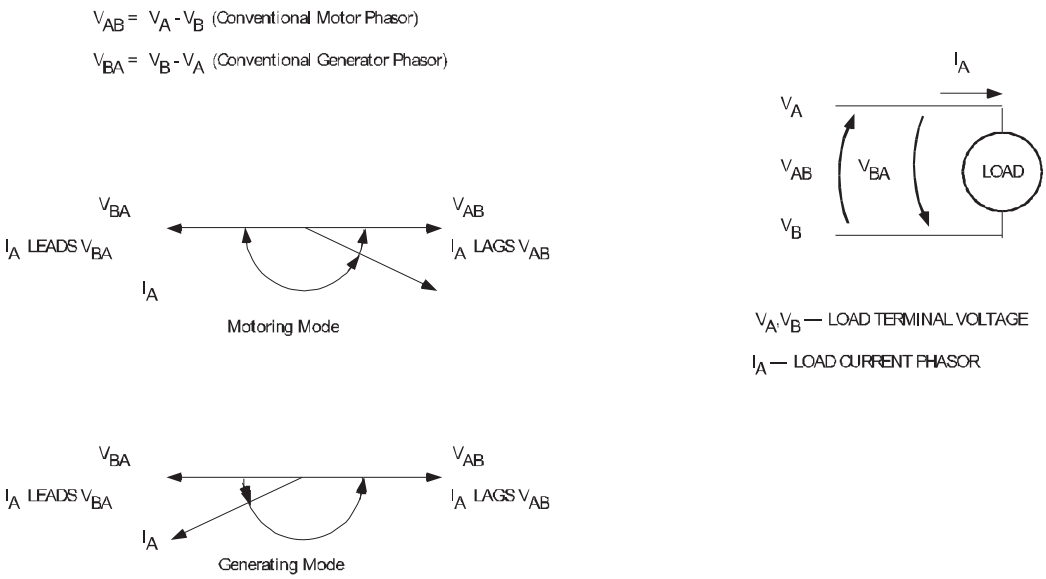


Figure 3–12: POWER FACTOR SENSING – MOTOR MODE VS. GENERATOR MODE

Therefore, a given line current that leads the conventional generator voltage phasor will lag the corresponding conventional motor phasor. The diagram above shows that IA is lagging VAB (conventional motor phasor) while it is leading VBA (conventional generator phasor).

This confusion can be eliminated by defining one terminal voltage phasor for both generating and motoring modes. Simply, if VAB is used as the reference phasor, then the leading power factor is always when the synchronous machine is producing reactive power and lagging power factor when it is consuming reactive power.

This is the approach that is taken with the PF display for the SPM. When the motor/generator is producing reactive kVA the sign of the power factor is displayed plus (+), indicating leading power factor, regardless of the operating mode. When it is consuming reactive kVA the power factor is negative (–).

Therefore, whether the machine is motoring or generating, pull-out protection is provided by limiting the degree of lagging power factor (under excitation) as detected by the SPM.

The power factor regulation option also performs to force the field in advance of a pull-out condition regardless of whether the machine is operating as a motor or a generator.

3.2.10 POWER FACTOR REGULATION

Power factor regulation is useful in those applications where motors are subjected to high-level transient impact loads (such as chipper drives). The PF regulator senses the power factor dip that occurs when the motor is loaded and causes the SCR Exciter to respond with a boosted output. As a result, the pull-out torque of the synchronous motor is increased for the duration of the transient load. After the load subsides, the regulator senses an excessive leading power factor and causes the SCR to reduce its output. This automatic boosting of field current to avoid pull-out is called field forcing. The Power Factor regulator thus provides automatic boosting when field forcing is required and economical low field operation when the motor is idling.

Another application of the power factor regulator is to control power factor swings that result from various levels of loading so as not to cause fluctuations in the plant system voltage.

The SPM provides the control signal to the variable SCR exciter when PF regulation is required. See the following figure for a functional operation overview of this feature.

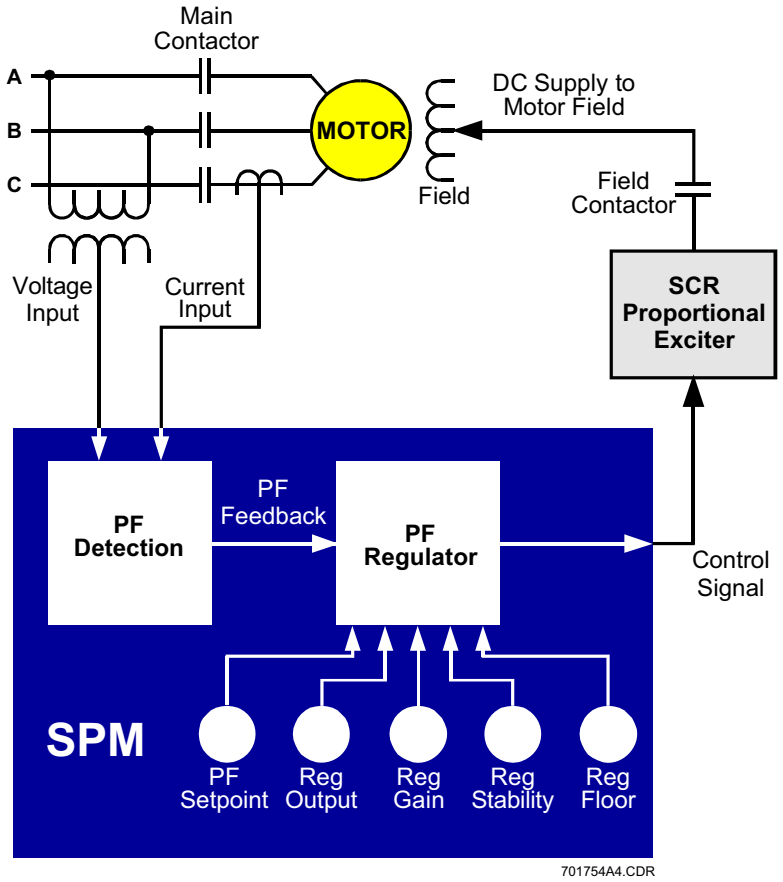


Figure 3–13: POWER FACTOR REGULATION

3.3.1 DESCRIPTION

A brushless controller provides functions relevant to starting and protecting a brushless synchronous motor. To understand the functional requirements, it is necessary to review the construction of a brushless motor.

3.3.2 BRUSHLESS MOTOR REVIEW

A brushless motor is like a conventional slip ring motor in that it has rotor-mounted field poles. These poles must have DC supplied to their windings so they can "lock" onto the rotating stator field and run in synchronism. Also, like the slip-ring motor, amortisseur windings are built into the rotor pole tips to provide acceleration and damping torque during starting and normal operation. During start, the motor accelerates to near synchronous speed. When the rotor is close enough to synchronous speed for the field poles to pull the rotor into synchronism, DC is applied to the main field and the rotor pulls into step, normally operating at a power factor equal to or more leading than unity.

The brushless motor has, as its name implies, no brushes or slip-rings. Instead, it contains a rotating exciter with stator mounted DC windings and the armature winding on the rotor. A rotor-mounted, solid-state rectifier converts the AC from the exciter to DC for the main-field poles. The silicon controlled rectifiers (SCRs) and control circuitry are rotor-mounted, along with the field discharge resistor, to control the application of DC to the main field at proper rotor speed and angle. The schematic below shows that the actual field control is provided with the motor and is not part of the motor controller.

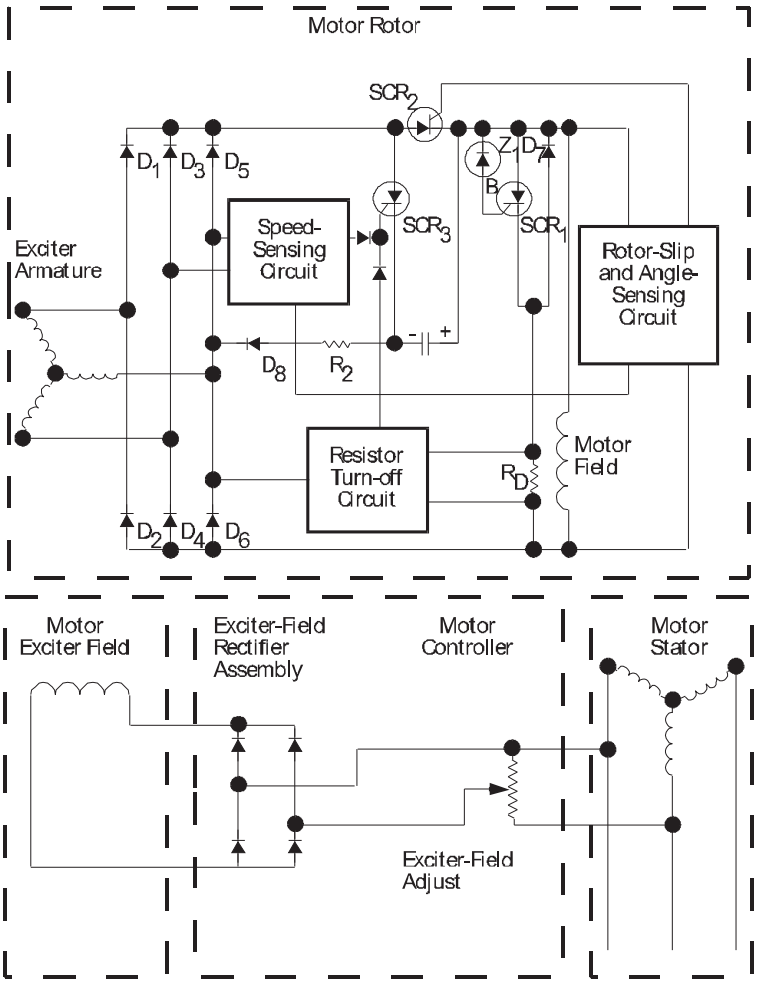


Figure 3–14: ROTATING RECTIFIER EXCITER WITH SYNCHRONOUS MOTOR

3.3.3 STARTING THE BRUSHLESS MOTOR

The brushless motor is started by first applying power to the stator windings then applying DC to the exciter field. See Figure 2–3: TYPICAL WIRING DIAGRAM on page 2–4 for details. There are two basic timing functions a brushless controller must provide during start:

1. Apply DC to exciter (not main) field a given preset time after stator windings are energized.
2. Enable the power factor, pull-out protection, and provide a contact for signaling external automatic motor loading devices for motor loading. This is determined by a second given pre-set time delay that allows sufficient time after the application of the exciter field for the motor to synchronize and stabilize.

Both of these times can be entered as setpoint parameters in the SPM. (See programming, Section 4-9.)

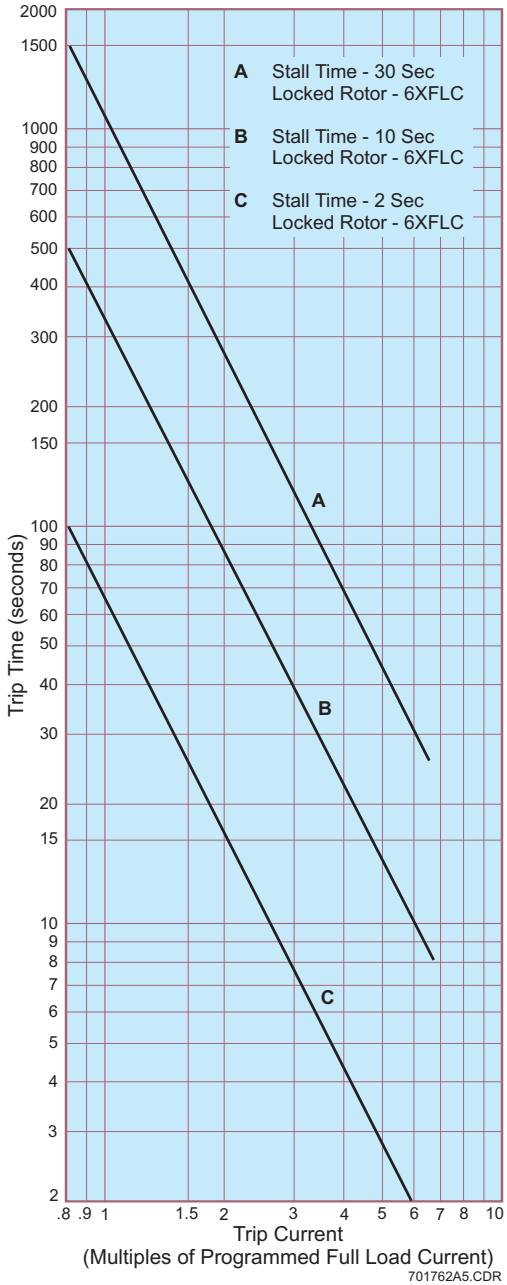


Figure 3–15: BRUSHLESS STALL/ACCELERATION CHARACTERISTIC

3.3.4 STALL PROTECTION

Stall protection is derived from stator current inputs from two lines feeding the motor. The protection characteristic is shown in Figure 3–15: BRUSHLESS STALL/ACCELERATION CHARACTERISTIC on page 3–18. After the motor synchronizes, the SPM monitors motor cool down approximately every 20 minutes rate to provide protection against motor abuse from too-frequent starting. The SPM will indicate on the display the required wait time period that must be allowed before attempting a restart on a motor that has been shutdown from a stall protective operation, or one in which two or more rapidly successive start/stop operations have been performed.

3.3.5 POWER FACTOR (PULL-OUT) PROTECTION

The power factor protection for brushless control operates as power factor protection for collector-ring motors described in Section 3.2.6. However, current I_3 is derived internally to the SPM by algebraically summing currents at the I_1 and I_2 inputs.

NOTE

It is important to connect current inputs for I_1 and I_2 as shown in Figure 8 for brushless machines.

Only the ride-through mode is available for brushless machines. If an attempt to resynchronize is desirable, set the "PF trip delay" parameter for one or two seconds. If the motor slips a pole in this condition, the rotor-mounted, control device will remove the field instantaneously. When, and if, the motor recovers from the disturbance, the main field will be applied. If it does not recover within the "PF trip time delay" the motor will trip.

If no attempt to resync is desirable, set the "PF trip time delay" parameter to 0.1 second. This time will be too short for the power factor to recover following a slipped pole condition and the motor will trip on lagging power factor.

3.3.6 POWER FACTOR REGULATION

Power factor regulation is not recommended on brushless machines due to instability problems arising from the long time constant of the rotating exciter field.

4.1.1 DESCRIPTION

This chapter provides all the necessary information to install and/or upgrade a previous installation of the SPMPC software, and write/edit setpoint files.

NOTE

The SPMPC software is only compatible with firmware versions 200 and higher.

The following sections are included in this chapter:

- System requirements
- SPMPC software version for previous installation check
- SPMPC software installation/upgrade procedure
- SPMPC software system configuration
- Creating/Editing/Upgrading/Downloading Setpoint Files
- Printing Setpoints and Actual Values
- Using Trending

The following minimum requirements must be met for the software to operate properly.

- Processor: minimum 486, Pentium recommended
- Memory: minimum 4 MB, 16 MB minimum recommended (540 K of conventional memory)
- Hard Drive: 20 MB free space required before installation of PC program.
- O/S: minimum Windows 3.1, Windows NT or Windows 95/98/2000 recommended
  Windows 3.1 Users must ensure that SHARE.EXE is installed.

If a version of the SPMPC software is currently installed, note the path and directory name as this information will be needed when upgrading.

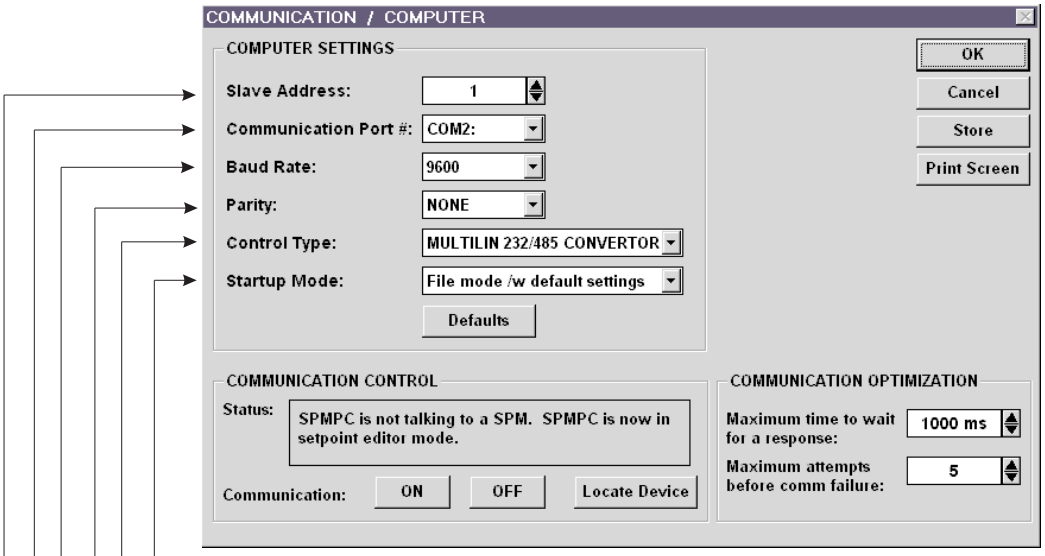
Installation of the SPMPC software is accomplished as follows:

1. Ensure that Windows is running on the local PC.
2. Insert the GE Multilin Products CD into your CD-ROM drive or point your web browser to the GE Multilin website at www.GEindustrial.com/pm. With Windows 95/98, the Product CD will launch the welcome screen automatically. Since the Products CD is essentially a “snapshot” of the GE Multilin website, the procedures for installation from the CD and the web are identical.

Figure 4–1: GE MULTILIN WELCOME SCREEN

3. Click the **Index by Product Name** item from the main page and select **SPM Synchronous Motor Protection and Control** from the product list to open the SPM product page.
4. Click the **Software** item from the Product Resources list to bring you to the SPM software page.
5. The latest version of the SPMPC software will be shown. Click on the **SPMPC Program** item to download the installation program to your local PC. Run the installation program and follow the prompts to install to the desired directory. When complete, a new GE Multilin group window will appear containing the SPMPC icon.

1. Connect the computer running the SPMPC program to the relay via the RS485 port and start the SPMPC software.
2. SPMPC will not automatically communicate with the relay unless that function is enabled. (see startup mode below). The screen will display the SPM firmware revision if communications is established.
3. To setup communications, select the **Communication > Computer** menu item.



Set the **Startup Mode** based upon user preference. In the "Communicate with Relay" mode, SPMPC will attempt to establish communications immediately upon startup. While in the "File mode /w default settings", SPMPC waits for the user to click the **ON** button before attempting communications – this mode is preferred when SPMPC is being used without an attatched SPM.

Set **Control Type** to match the type of RS232/RS485 converter. If connected through a GE Power Management F485 converter unit, select "MULTILIN 232/485 CONVERTOR". If connected through a modem, select "Modem". If a third-party RS232/RS485 converter is being used, select the appropriate control type from the available list based upon the manufacturer's specifications.

Set **Parity** to match the PARITY setpoint.

Set **Baud Rate** to match the BAUD RATE setpoint.

Set **Communication Port** to the COM port on your local PC where the SPM is connected (e.g. COM1 or COM2). On most PCs, COM1 is used by the mouse device, leaving COM2 available for communications.,

Set **Slave Address** to match the SLAVE ADDRESS setpoint programmed in the SPM.

Figure 4–2: COMMUNICATION/COMPUTER WINDOW

4. To begin communications, click the ON button in the Communication section of the dialog box above. The Status section indicates the communication status. If communication is successfully established, the message "Program is now talking to a Multilin device" is displayed. As well, the status at the bottom right hand corner of the screen indicates "Communicating".

Creating a new SPM setpoint file is accomplished as follows”

1. Start the SPMPC software. It is not necessary to have a SPM connected to the computer. The SPMPC status bar will indicate that the program is in "Polling Relay" mode and "Not Communicating"
2. Choose an appropriate section of setpoints to program from the **Programming** menu (e.g. **Programming > Configuration**) and enter the new setpoints. When finished, click OK. The information is automatically stored to the computer's scratchpad memory.

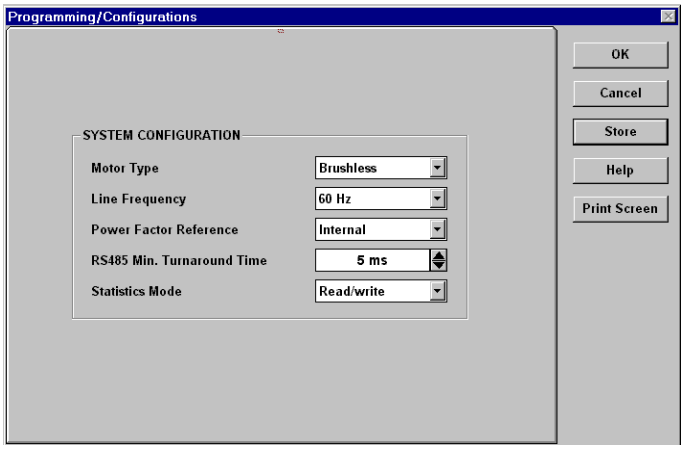
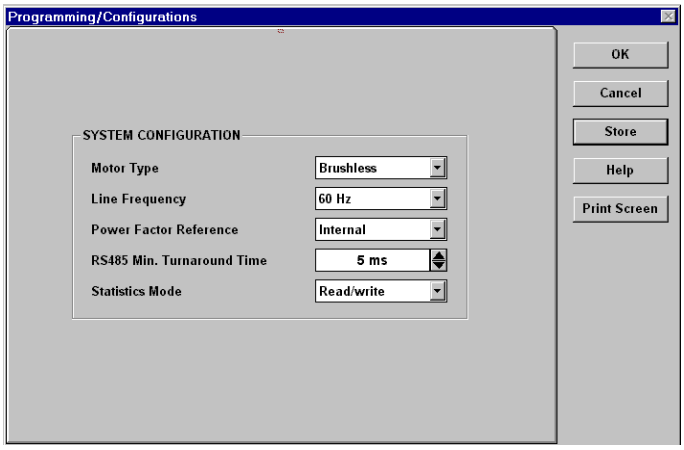


Figure 4–3: PROGRAMMING / CONFIGURATION WINDOW

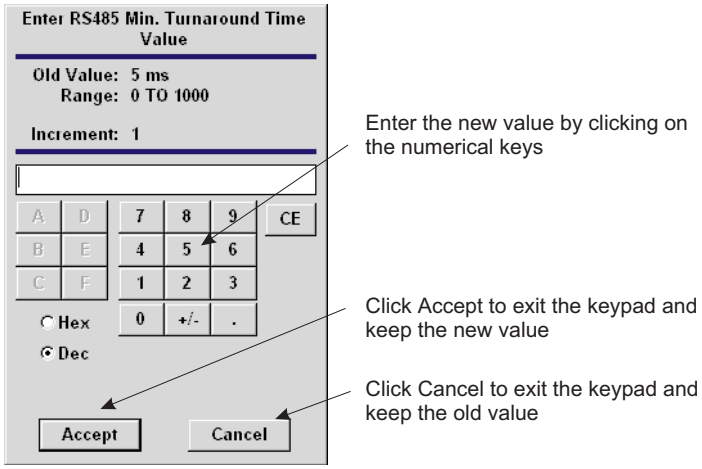
3. Repeat step 2 until all the desired setpoints are programmed.
4. Select the **File > Save As** menu item to store this file to disk. Enter the location and file name of the setpoint file with a file extension of '.SPM' and select **OK**.
5. The setpoint file is now saved to disk. See Section 4.1.6: LOADING SETPOINTS FROM A FILE on page 4–6 for instructions on downloading a setpoint file to the SPM relay.

The following example illustrates how to enter setpoints using the SPMPC program.

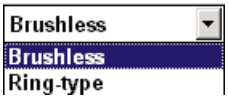
1. Select the **Programming > Configuration** menu item. The following dialog box prompts for the configuration information.



2. For setpoints requiring numerical values (e.g. RS485 Min. Turnaround Time), change the value by clicking the up/down arrows at the right side of the box. Alternately, you may click the mouse pointer anywhere inside the setpoint value box to display a numerical keypad showing the OLD value, RANGE, and INCREMENT of the setpoint value being modified.



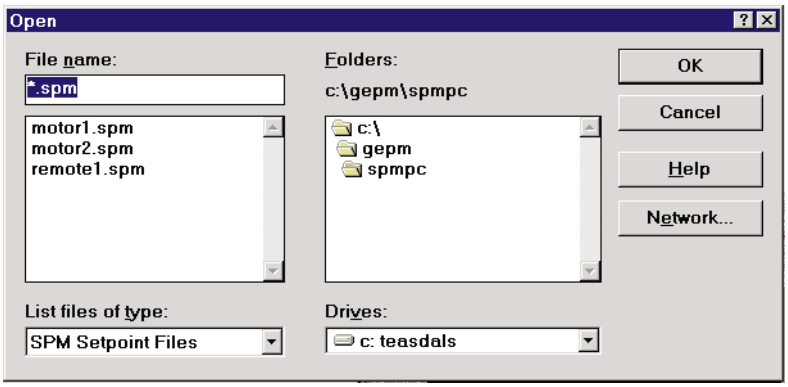
3. For setpoints requiring non-numerical values (e.g. Motor Type), clicking anywhere inside the setpoint box causes a selection menu to be displayed.



4.1.6 LOADING SETPOINTS FROM A FILE

Loading the SPM with setpoints from a file is accomplished as follows:

1. Select the File > Open menu item
2. SPMPC launches the Open window listing all filenames in the SPM default directory with the extension SPM. Select the file to download and click OK.

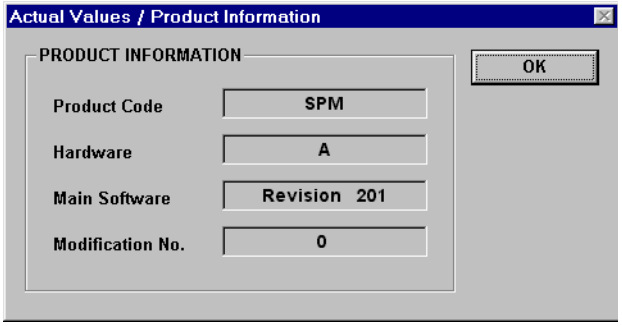


Select the **File > Send Setpoints to Relay** menu item. SPMPC will prompt to confirm or cancel the setpoint file transfer. Click **Yes** to download the setpoints to the SPM or click **No** to cancel.

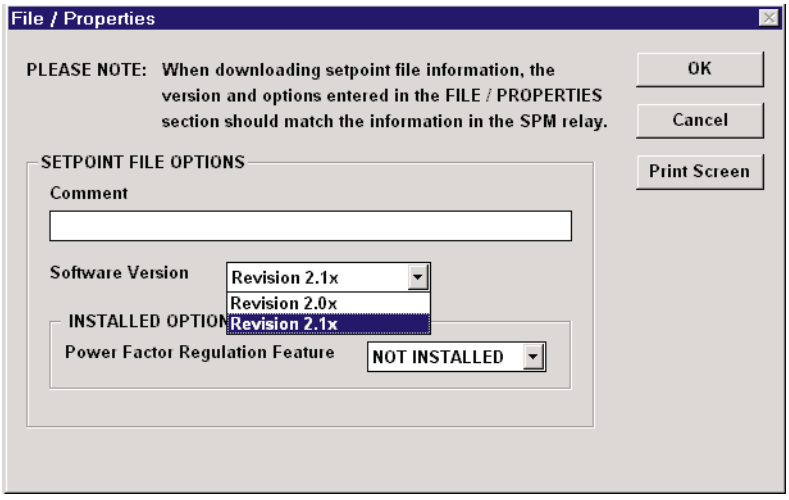
4.1.7 UPGRADING SETPOINT FILES TO A NEW REVISION

It may be necessary to upgrade the revision code for a previously saved setpoint file when the SPM firmware is upgraded.

1. To upgrade the revision of a previously saved setpoint file, run SPMPC and establish communications with the SPM through the RS485 connector.
2. Select the **Actual Values > Product Information** menu item and record the Main Software number of the re-lay's firmware, e.g. 201.



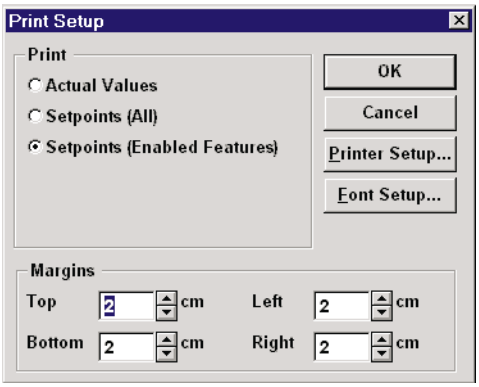
3. Next, select the **File > Open** menu item and enter the location and filename of the setpoint File to be downloaded to the connected relay. When the file is open, SPMPC will be in "Editing File" mode and "Not communicating".
4. Select the **File > Properties** menu item and note the version code of the setpoint file. If the Main Software number of the setpoint file (e.g. 20x) is different than the Main Software number of the firmware (noted in Step 2 as 201), use the pull-down tab to select the revision code that matches the firmware and click OK.



5. Select the File > Save menu item to save the setpoint file.

See the previous section for instructions on loading this setpoint file to the SPM relay.

1. Start the SPMPC software.
2. Select the **File > Open** menu item to open a previously saved setpoint file or establish communications with a connected SPM to print the current setpoints.
3. Select the **File > Print Setup** menu item and select one of the printing options (actual values, setpoints, or setpoints for enabled features). Click **OK** to continue.



4. Select the **File > Print** menu item and click OK to send the setpoint file to the connected printer.

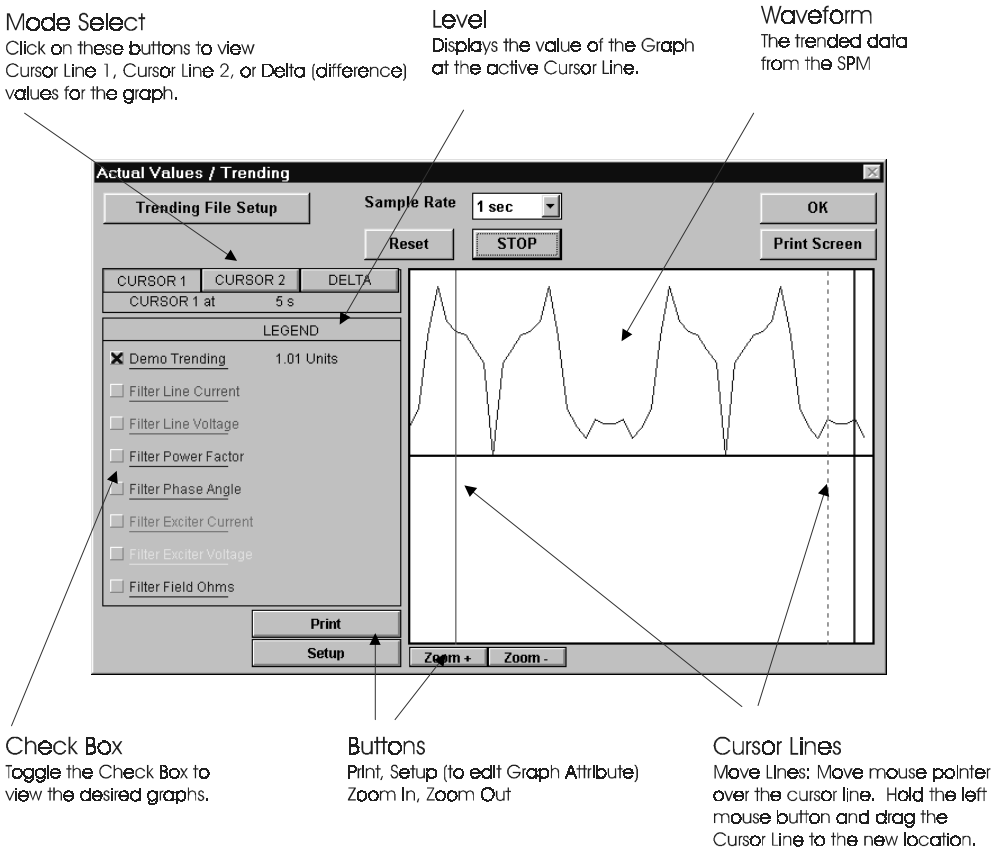
4.1.9 TRENDING

Trending from the SPM can be accomplished with the SPMPC software. Many different parameters can be trended and graphed at sampling periods ranging from 1 second up to 1 hour.

The parameters which can be Trended by the SPMPC program are:

Filter Line Current	*Filter Exciter Current*
Filter Line Voltage	*Filter Exciter Voltage*
Filter Power Factor	*Filter Field Ohms*
Filter Phase Angle	*Demo Trending*

1. To use the Trending function, run SPMPC and establish communications with a connected SPM relay.
2. Select the **Actual Values > Trending** menu item open the Trending window.



3. Press the Setup button to enter the Graph Attribute window.
4. Program the Graphs to be displayed by selecting the pull down menu beside each Graph Description. Change the Color, Style, Width, Group #, and Spline selection as desired. Select the same Group # for all parameters to be scaled together.
5. Select **Save** to store these Graph Attributes, and **OK** to close this window.
6. Use the pull-down menu to select the Sample Rate, click the checkboxes of the Graphs to be displayed, and select **RUN** to begin the trending sampling.
7. The **Trending File Setup** button can be used to write the graph data to a file in a standard spreadsheet format. Ensure that the **Write Trended Data to File** box is checked, and that the **Sample Rate** is at a minimum of 5 seconds. Set the file capacity limit to the amount of memory available for trended data.

4.2.1 DESCRIPTION

The SPM is a user programmable device with a wide range of setpoints, configurations, and calibration values that enable operation with a wide variety of ring-type and brushless synchronous motors. This section deals with programming the SPM for a ring-type motor. The setpoints will be explained and a practical example will be given. The example may be followed step by step by the operator as a guide to program the SPM for their motor.

- **GE Key**. This key is used to enter or exit the different modes of the SPM (STAT MODE, PROGRAMMING MODE, and TEST MODE). It is also used to cancel an operation, such as changing a setpoint.
- **SCROLL Keys**. These keys are used to scroll through the various menus, setpoints, configuration parameters, etc. When the motor is in running mode, pressing either of these keys will halt the display from scrolling. They can then be used to step through the displayed values one at a time. Pressing and holding this key will resume the automatic scrolling of the display.

  When changing a setpoint or other parameter, pressing and holding either of the SCROLL keys down will put the values being changed into a decade incremental scroll. Thus, changing a setpoint from 1 to 1000, the value would start to increment by the decade value (10, 100, or 1000) after every decade (after reaching 10, it increments by 10, after reaching 100, it increments by 100).
- **ENTER Key**. This key is used to make a selection or acts as an enter key, as prompted by the menu on the display. This key must be pressed when setpoints, configuration parameters or calibration values are selected to be changed. It must also be pressed to save such changes.

  The SPM has a "smart" parameter menu for setpoints that does not allow the user to enter values outside of the valid range and automatically checks for setpoint dependencies.

4.2.2 CHANGING SETPOINTS

To change SPM setpoints, the user must enter the PROGRAMMING MODE. This can be accomplished with the motor either off or in running mode. Use the following procedure to enter the PROGRAMMING MODE:

1. With the display indicating the following, press the GE key (items in bold italics indicate that they should be blinking on the screen):

   Collr-Ring Motor
   SPM READY

2. The display should now indicate that the unit is in STAT MODE. Press the GE key.

   STAT MODE
   SCROLL for menus

3. Press the GE key. The display should now indicate that the unit is in PROGRAMMING MODE:

   PROGRAMMING MODE
   SCROLL PASSWORD

4. Use the ▽/△ keys to change the password and then press the ENTER key to enter the password.

   PASSWORD: 0000
   ENTER to verify

5. The display should now indicate the CONFIGURATIONS menu or the CALIBRATION menu (depending upon which scroll key was pressed). Use the ▽/△ keys to select the SETPOINTS menu.

   SETPOINTS?
   ENTER for menus

6. Press the ENTER key to enter the setpoints menu. Once in the SETPOINTS menu, use the ▽/△ keys to move through the different setpoints.

7. To change a setpoint, press the ENTER key as prompted:

   PF TRIP: –0.80
   SELECT to modify

8. Once the setpoint has been selected, the value of the setpoint should blink. Use the ▽/△ keys to change the value of the setpoint and then press the ENTER key to continue. If you choose not to change this setpoint once it has been selected, pressing the GE key deselects the setpoint.

   PF TRIP: –0.80
   SCROLL to change

9. Additional setpoints can be changed using the above procedure. When all setpoint changes have been accomplished, press the GE key. This will return the display to the SETPOINTS main menu. Press the GE key again and the display will ask to verify that changes should be save. Press ENTER to save the setpoints, otherwise press the GE key if you do not want to save the changes.

   SAVE CHANGES?
   ENTER to save ...

10. Upon pressing ENTER (to save the setpoint changes) or the GE key (not wanting to save setpoint changes), the display returns to the PROGRAMMING MODE menu. Press the GE key once to go into TEST MODE and a second time to return to the SPM READY display.

4.2.3 CHANGING CALIBRATION VALUES

To change the calibration values on the SPM, the user must enter the PROGRAMMING MODE. This can be accomplished only when the SPM is off. To enter the PROGRAMMING MODE, use the following procedure:

1. With the display indicating the following, press the GE key (items in bold italics indicate that they should be blinking on the screen):

   Collr-Ring Motor
   SPM READY

2. The display should now indicate that the unit is in STAT MODE:

   STAT MODE
   SCROLL for menus

3. The display should now indicate that the unit is in PROGRAMMING MODE:

   PROGRAMMING MODE
   SCROLL PASSWORD

4. Use the ▽/△ keys to change the password and then press the ENTER key to enter the password.

   PASSWORD: 0000
   ENTER to verify

5. The display should now indicate the CONFIGURATIONS menu or the CALIBRATION menu (depending upon which scroll key was pressed). Use the ▽/△ keys to select the CALIBRATION menu.

   CALIBRATION?
   ENTER for menus

6. Press the ENTER key to enter the set-points menu. Once in the CALIBRATION menu, use the ▽/△ keys to move through the different calibration parameters.

7. To change a calibration parameter, press the ENTER key as prompted:

   FS EXC VOLT: 1.00
   SELECT to modify

8. Once the calibration parameter has been selected, the value of the parameter should blink. Use the ▽/△ keys to change the value of the setpoint and then press ENTER to continue. If you choose not to change this setpoint once it has been selected, pressing the GE key deselects the setpoint.

   FS EXC VOLT: *1.00*
   SCROLL to change

9. Additional calibration parameters can be changed using the above procedure. When all calibration parameter changes have been accomplished, press the GE key. This will return the display to the CALIBRATION main menu. Press the GE key again and the display will ask to verify that changes should be save. Press ENTER to save the setpoints, otherwise press the GE key if you do not want to save the changes.

   SAVE CHANGES?
   ENTER to save ...

10. Upon pressing the ENTER key (to save the setpoint changes) or the GE key (not wanting to save setpoint changes), the display returns to the PROGRAMMING MODE menu. Press the GE key once to go into TEST MODE and a second time to return to the SPM READY display.

4.2.4 CHANGING CONFIGURATIONS

To change the SPM configuration, the user must enter the PROGRAMMING MODE. This can be accomplished with the motor either off or in the running mode. To enter the PROGRAMMING MODE, the following procedure must be used:

1. With the display indicating the following, press the GE key (items in bold italics indicate that they should be blinking on the screen):

   Collr-Ring Motor
   SPM READY

2. The display should now indicate that the unit is in STAT MODE:

   STAT MODE
   SCROLL for menus

3. Press the GE key. The display should now indicate that the unit is in PROGRAMMING MODE:

   PROGRAMMING MODE
   SCROLL PASSWORD

4. Use the ▽/△ keys to change the password and press ENTER to enter the password.

   PASSWORD: 0000
   ENTER to verify

5. The display should now indicate the CONFIGURATIONS menu or the CALIBRATION menu (depending upon which scroll key was pressed). Use the ▽/△ keys to select the CONFIGURATIONS menu.

   CONFIGURATIONS?
   ENTER for menus

6. Press the ENTER key to enter the setpoints menu. Once in the CONFIGURATIONS menu, use the ▽/△ keys to move through the different setpoints.

7. To change a configuration, press the ENTER key as prompted:

   MOTOR: Collr-Ring
   SELECT to modify

8. Once the configuration has been selected, the value of the setpoint should blink. Use the ▽/△ keys to change the value of the configuration and then press the ENTER key to continue. If you choose not to change this setpoint once it has been selected, pressing the GE key deselects the setpoint.

   MOTOR: *Collr-Ring*
   SCROLL TO CHANGE

9. Additional configurations can be changed using the above procedure. When all setpoint changes have been accomplished, press the GE Key. This will return the display to the CONFIGURATIONS main menu. Press the GE key again and the display will ask to verify that changes should be save. Press ENTER to save the configurations, otherwise press the GE key if you do not want to save the changes.

   SAVE CHANGES?
   ENTER to save ...

10. Upon pressing the ENTER key (to save the setpoint changes) or the GE key (not wanting to save setpoint changes), the display returns to the PROGRAMMING MODE menu. Press the GE key once to go into TEST MODE and a second time to return to the SPM READY display.

4.2.5 VIEWING & CHANGING STATUS MODE PARAMETERS

To view or change the SPM status information, the user must enter the STAT MODE. This can be accomplished with the motor either off or in running mode. Use the following procedure to enter the STAT MODE:

1. With the display indicating the following, press the GE key (items in bold italics indicate that they should be blinking on the screen):

   Collr-Ring Motor
   SPM READY

2. The display should now indicate that the unit is in STAT MODE:

   STAT MODE
   SCROLL for menus

3. Use the ▽/△ keys to scroll through the STAT MODE parameters.
4. If the SPM is configured such that status mode parameters are "read only", then these values can only be viewed and cannot be changed. If the SPM is configured such that status mode parameters are "read/write", then these values can be changed as follows.
5. Once the parameter that is to be changed is displayed on the display, press ENTER to select the parameter:

   MOTOR HRS: 0
   SELECT to modify

6. Use the ▽/△ keys to change the values of the selected parameter and then press the ENTER key to continue. If you choose not to change the parameter once it has been selected, pressing the GE key deselects the parameter.

   MOTOR HRS: *0*
   SCROLL to change

7. Additional parameters can be changed using the above procedure. When all parameter changes have been accomplished, press the GE Key. This will return the display to the STAT MODE main menu. Press the GE key again and the display will change to the PROGRAMMING MODE main menu. Pressing the GE key again puts the display into the TEST MODE main menu. Pressing the GE key gain will then return the display to the SPM READY display.

4.2.6 ALTERNATE MENU OPERATION

In order to view setpoints without changing values, or to view setpoints if the password is unknown, the alternate menu can be used. When the SPM is in the ready mode,

Collr-Ring Motor
SPM READY

press the ENTER key and the SPM will automatically switch into the alternate menu. The SPM will begin to automatically scroll through the setpoints. Pressing either of the ▽/△ keys once will halt the display. Pressing either of the ▽/△ keys repeatedly will allow the user to scroll through the setpoints manually. This allows the user to scroll through the setpoints using the ▽/△ keys but does not allow setpoints to be changed. To return to the SPM READY display, press the ENTER key.

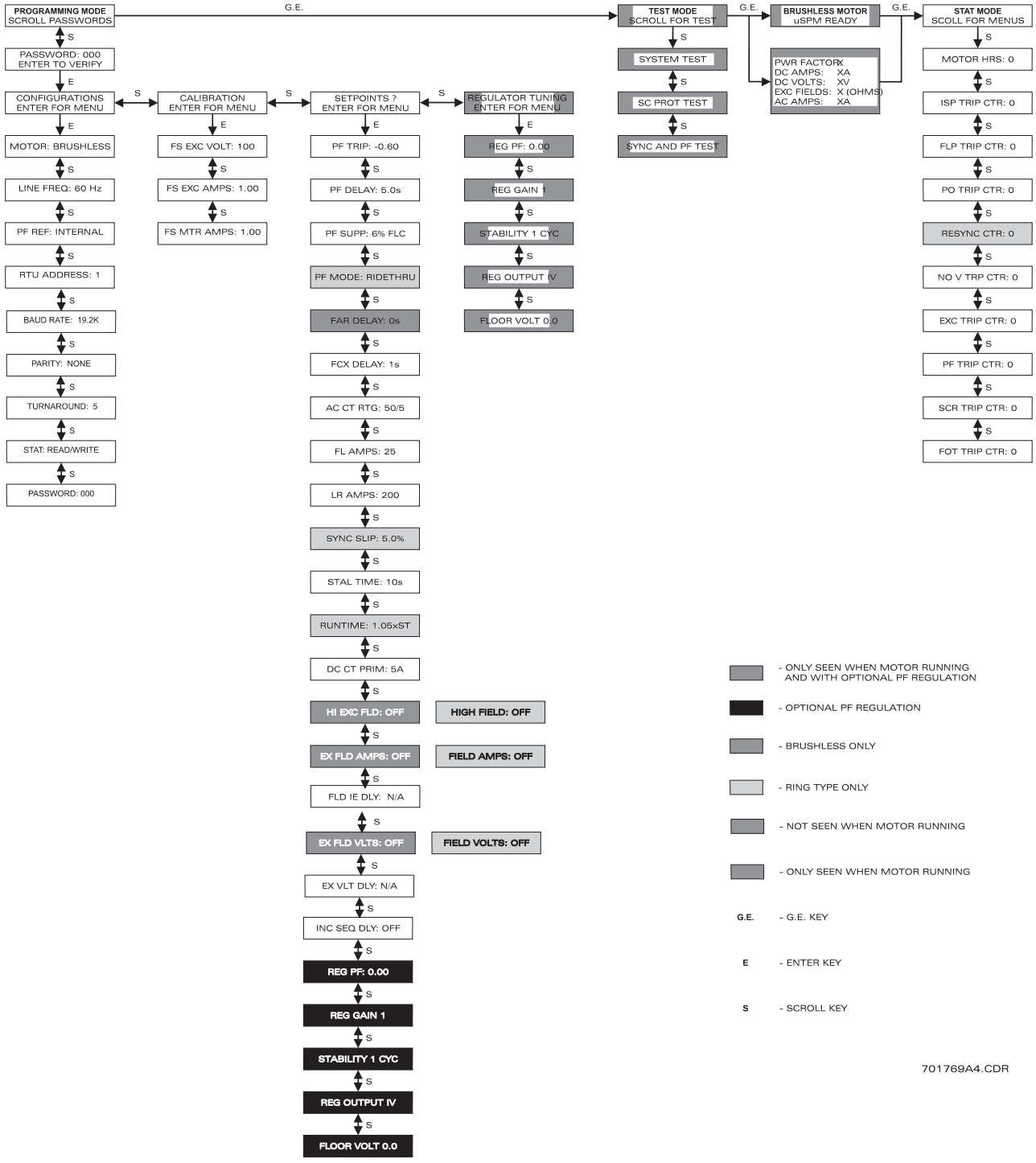


Figure 5–1: SPM DISPLAY STRUCTURE

5.2.1 POWER FACTOR TRIP

PF TRIP: –0.60 ENTER to modify	*Range: –0.60 to 1.00* *Step: 0.01*

FUNCTION:

The **PF TRIP** setpoint represents the value of lagging power factor that causes a trip or resynchronizing attempt during motor operation. For example, if the trip power factor is set at 0.85 lagging (–0.85), the SPM trips if the power factor falls below 0.85 for a time longer than the **PF DELAY** setpoint.

MOTOR TYPE:

Collector-Ring and Brushless

NOTE:

The SPM automatically suppresses the power factor trip element until the programmed **FCX DELAY** times out.

5.2.2 POWER FACTOR DELAY

PF DELAY: 1.0 s ENTER to modify	*Range: 0.1 to 10.0 seconds* *Step: 0.1*

FUNCTION:

The **PF DELAY** setpoint represents the elapsed time delay after the power factor dips below the **PF TRIP** setpoint (or after the line current remains greater than four times the **FL AMPS** setpoint) before the SPM initiates tripping action for power factor trip (or pull-out trip).

MOTOR TYPE:

Collector-Ring and Brushless

5.2.3 POWER FACTOR SUPRESSION

PF SUPP: 6% FLC ENTER to modify	*Range: 6%, 50% FLC*

FUNCTION:

Power factor suppression is used to inhibit **PF TRIP** or PULL-OUT trip action when the line current is less than the setpoint percentage of the full-load current (**FL AMPS**) setpoint.

MOTOR TYPE:

Collector-Ring and Brushless

5.2.4 POWER FACTOR MODE

PF MODE: ridethru
ENTER to modify

Range: ridethru, resync

FUNCTION:

Ridethru Mode: This mode allows the motor to "ride through" power factor dips of less duration than the **PF DELAY** but will protect against cyclical power factor dips. Brushless motors are automatically in ridethru mode.

Resync Mode: Upon measuring a power factor below the **PF TRIP** setpoint, the unit de-energizes the FAR and FCX relays and attempts to resynchronize the motor. The motor continues to run with the field removed for the programmed **PF DELAY**, and if resynchronization does not occur within this time a **PWR FACTOR TRIP** occurs, operating the trip relay and stopping the motor.

MOTOR TYPE:

Collector-Ring

5.2.5 FIELD APPLICATION RELAY DELAY

FAR DELAY: 0 s
ENTER to modify

Range: 0 to 90 seconds
Step: 1

FUNCTION:

This setpoint provides for a time delay in closing the field application relay (FAR) to apply DC to the exciter after the stator windings are energized.

MOTOR TYPE:

Brushless

5.2.6 FIELD CONTACTOR AUXILIARY RELAY DELAY

FCX DELAY: 1 s
ENTER to modify

Range: 1 to 6 seconds for Collector-Ring
1 to 90 seconds for Brushless
Step: 1

FUNCTION:

Program **FCX DELAY** time to enable power factor protection, field overtemperature protection, field loss protection and auto-loading FCX relay operation. Timing begins with FAR relay operation.

MOTOR TYPE:

Collector-Ring and Brushless

5.2.7 AC CT PRIMARY RATING

AC CT RTG: 50/5 ENTER to modify	*Range: 5 to 2000 A* *Step: 5*

FUNCTION:

The phase CT ratio supplied with the starter must be entered here. Enter only primary amperes. A 5 A secondary is assumed.

MOTOR TYPE:

Collector-Ring and Brushless

NOTE:

The value entered here affects the valid range of the motor full load current (**FL AMPS**) setpoint.

5.2.8 MOTOR FULL LOAD AMPS

FL AMPS: 25 ENTER to modify	*Range: 2 to 2000 A* *Step 1* *Dependent on the* **AC CT RTG** *setpoint*

FUNCTION:

This setpoint is the motor-nameplate, full load current. It is related to the **AC CT RTG** setpoint. The minimum and maximum current is determined by the formula below. Changes to the **AC CT RTG** setpoint may cause this setpoint to become invalid (out of range).

$$\text{minimum } \textbf{FL AMPS} = 2 \times \frac{\textbf{AC CT RTG}}{5}, \text{ maximum } \textbf{FL AMPS} = \textbf{AC CT RTG}$$

MOTOR TYPE:

Collector-Ring and Brushless

NOTE:

The value entered here affects the valid range of the motor locked rotor current (**LR AMPS**) setpoint.

5.2.9 MOTOR LOCKED ROTOR AMPS

LR AMPS: 200 ENTER to modify	*Range: 4 to 24000 A* *Step: 1* *Dependent on the* **FL AMPS** *setpoint*

FUNCTION:

This setpoint represents the motor locked rotor current and is related to the **FL AMPS** setpoint. The minimum and maximum current is determined by the formula below. Changes to the **AC CT RTG** and/or the **FL AMPS** setpoints may cause this setpoint to become invalid (out of range).

$$\text{minimum } \textbf{LR AMPS} = 2 \times \textbf{FL AMPS}, \text{ maximum } \textbf{LR AMPS} = 12 \times \textbf{FL AMPS}$$

MOTOR TYPE:

Collector-Ring and Brushless

5.2.10 SYNCHRONOUS SLIP

SYNC SLIP: 5.0%
ENTER to modify

Range: 0.5 to 10%
Step: 0.1%

FUNCTION:

The value stored here is the slip at which the SPM will close the field contactor (FAR). It is expressed as percent slip.

MOTOR TYPE:

Collector-Ring

EXAMPLE:

To close the field contactor (apply the field) when the motor reaches 94.5% of synchronous speed, the **SYNC SLIP** setpoint is determined as follows:

100% speed – 94.5% speed = 5.5% sync slip

5.2.11 STALL TIME

STALL TIME: 10 s
ENTER to modify

Range: 1 to 40 seconds
Step: 1

FUNCTION:

This setpoint determines the allowable time that power may be applied to the motor during locked rotor conditions. This information may normally be found on the motor control data sheet available from the motor manufacturer.

MOTOR TYPE:

Collector-Ring and Brushless

5.2.12 RUN TIME

RUN TIME: 1.05 x ST
ENTER to modify

Range: 1.05, 1.46, 2.05, 3.00 x **STALL TIME**

FUNCTION:

Run time is the time that the motor may run at 50% speed and is expressed as a multiple of the allowable motor stall time.

MOTOR TYPE:

Collector-Ring

EXAMPLE:

If the motor stall time is 10 seconds and **RUN TIME** is set to 3.00, then the motor can run at:

3.00 × 10 sec. = 30 seconds at 50% speed

5.2.13 DIRECT CURRENT CT PRIMARY RATING

DC CT PRIM: 5 A ENTER to modify	*Range: 5 to 1000 A* *Step: 1*

FUNCTION:

The primary ampere rating (not the ratio) stamped on the DC Current Transformer (DCCT) is entered here if one turn is passed through the DCCT window. If more than one turn is used, divide the DCCT primary ampere rating by the number of turns and enter this number here.

MOTOR TYPE:

Collector-Ring and Brushless

NOTE:

The DCCT is available as a separate accessory in the PG2SPM or PG4SPM packages along with the necessary CM (calibration module). These packages are required for overtemperature or current loss protection.

The value entered here affects the valid range of the **HIGH FIELD** / **HI EXC FIELD** setpoint.

APPLICATION:

The standard DCCT200 (from PG2SPM package) has a rated 200 A primary and a 50 mA secondary (4000:1 ratio). The DCCT terminals connect to CM terminals 7 and 8 (the polarity not important). Multiple turns of field cable through the DCCT window may be required to obtain the proper effective CT ratio. Determine your motor rated field (or exciter field) current and use the following table to determine the number of field cable turns through the DCCT and effective rating to enter as the **DCCT PRIM** setpoint.

Table 5–1: DCCT SETUP

DC FIELD AMPS RANGE	RECOMMENDED DCCT CABLE SIZE	NUMBER OF TURNS	DCCT PRIM SETPOINT
1 to 3 A	18 AWG	40	5 A
3.01 to 8 A	16 AWG	20	10 A
8.01 to 15 A	10 AWG	10	20 A
15.01 to 24 A	8 AWG	6	33 A
24.01 to 34 A	6 AWG	4	50 A
34.01 to 60 A	4 AWG	2	100 A
60.01 to 75 A	2 AWG	2	100 A
75.01 to 100 A	2 AWG	1	200 A
100.1 to 133 A	1/0 AWG	1	200 A
133.1 to 154 A	2/0 AWG	1	200 A

5.2.14 FIELD OVERTEMPERATURE (HIGH FIELD OHMS) PROTECTION

HIGH FIELD: OFF **ENTER to modify**	*Collector-Ring:*	*Range: see below* *Step: see below*
HI EXC FLD: OFF **ENTER to modify**	*Brushless:*	*Range: see below* *Step: see below*

FUNCTION:

The calculation of field (exciter) voltage divided by field (exciter) current yields field ohms. Tripping action is initiated if the calculated resistance exceeds the **HIGH FIELD** (**HI EXC FLD**) setpoint, indicating a field overtemperature condition. A separate accessory package (PG2SPM or PG4SPM) is required to utilize this feature.

Table 5–2: FIELD OVERTEMPERATURE RANGE / STEP VALUES

DC CT PRIM SETPOINT	HIGH FIELD/HIGH EXC FLD	
	MINIMUM	MAXIMUM
5 to 19 A	10 Ω	450 Ω
20 to 200 A	1 Ω	40 Ω
201 to 1000 A	0.20 Ω	5 Ω

FIELD OHMS VALUE	STEP
< 1 Ω	0.01 Ω
< 10 Ω	0.1 Ω
< 450 Ω	1 Ω

MOTOR TYPE:

Collector-Ring or Brushless

APPLICATION:

This function emulates a resistance temperature detector (RTD) on the field windings. The resistance of an RTD is temperature dependent – it increases as the temperature increases. In this case, the RTD behavior is emulated by examining the field voltage and current. As the ratio of field voltage to field current increases, the field resistance increases, indicating an increase in temperature of the field windings.

The motor nameplate contains the motor's maximum temperature rise and field resistance. This information is used with the multiplier from the table below to determine the maximum field ohms, and therefore the maximum field winding temperature, at which the motor should be allowed to operate.

Table 5–3: FIELD OHMS MULTIPLIER

RISE °C	MULTIPLIER
0	1.0
5	1.02
10	1.04
15	1.06
20	1.08
25	1.10
30	1.12

RISE °C	MULTIPLIER
40	1.15
50	1.19
60	1.23
70	1.27
80	1.31
90	1.35
100	1.39

RISE °C	MULTIPLIER
110	1.42
120	1.46
130	1.50
140	1.54
150	1.57
160	1.60
170	1.64

EXAMPLE:

A motor with a nameplate field resistance of 2 Ω at 25°C with insulated copper windings has a maximum temperature rise of 80°C. This corresponds to a field resistance of 1.31 times the resistance at 25°C. So, the **FIELD OHMS** setpoint is set to $1.31 \times 2\ \Omega = 2.62\ \Omega$.

5.2.15 FIELD UNDERCURRENT

FIELD AMPS: OFF ENTER to modify	*Collector-Ring:*	*Range: OFF, 0.1 to 1000 A* *Step: 0.1 for values <10 A; 1 for values ≥10 A*
EX FLD AMPS: OFF ENTER to modify	*Brushless:*	*Range: OFF, 0.1 to 1000 A* *Step: 0.1 for values <10 A; 1 for values ≥10 A*

FUNCTION:

The value programmed here determines the minimum permissible field current that the SPM recognizes as valid. If the field current falls below this setpoint, the SPM will trip and display a **FIELD LOSS TRIP** fault. A separate accessory package (PG2SPM or PG4SPM) is required to utilize this feature.

MOTOR TYPE:

Collector-Ring or Brushless

5.2.16 FIELD UNDERCURRENT DELAY

FLD IE DLY: 0.3 s ENTER to modify	*Range: 0.3 to 5.0 seconds* *Step: 0.1 second*

FUNCTION:

The field undercurrent delay represents the time delay that will elapse after the Field Amps falls below the programmed setpoint before the SPM initiates tripping action for Field Undercurrent (**FIELD LOSS TRIP**). The Field Amps Option must be enabled before this feature can be used.

MOTOR TYPE:

Collector-Ring or Brushless

5.2.17 FIELD UNDERVOLTAGE

FIELD VOLTS: OFF ENTER to modify	*Collector-Ring*	*Range: OFF, 1 to 200 V* *Step 1*
EX FLD VLTS: OFF ENTER to modify	*Brushless*	*Range: OFF, 1 to 200 V* *Step 1*

FUNCTION:

This parameter determines the field undervoltage that will initiate a **CHECK EXCITER** condition. For example, if the exciter normally provides 100 V to the field circuit and this setpoint is programmed for 30 V, then the SPM will trip and display **CHECK EXCITER** if the field voltage falls below the setpoint. The SPM checks the exciter voltage before allowing the motor to start and will not allow a start if the voltage is not present but, will not require a reset once voltage is reestablished. The SPM displays **CHECK EXCITER** and initiates a trip anytime the motor is running and the field voltage is below this setpoint. In this case a reset is required. The exciter output must be hooked up to the SPM via the included VDN module. See installation for more details.

MOTOR TYPE:

Collector-Ring or Brushless

APPLICATION:

This function is supplied for equipment that has exciters energized prior to starting the motor. If the exciter is designed to be energized with motor starting (as with shaft connected rotating exciters), use the field current loss feature instead or a separate voltage relay for voltage check protection.

5.2.18 FIELD UNDERVOLTAGE DELAY

EX VLT DLY: 0.3 s **ENTER to modify**	*Range: 0.3 to 5.0 seconds* *Step: 0.1 second*

FUNCTION:

The exciter voltage delay setpoint is the time delay that will elapse after the exciter voltage falls below the programmed setpoint before the SPM initiates tripping action for field undervoltage (**CHECK EXCITER**)

MOTOR TYPE:

Collector-Ring or Brushless

NOTE:

The **EXCITER VOLTS** option must be enable before this feature can be used.

5.2.19 INCOMPLETE SEQUENCE DELAY

INC SEQ DLY: OFF **ENTER to modify**	*Collector-Ring*	*Range: 1 to 100 seconds, OFF* *Step 1*
INC SEQ DLY: OFF **ENTER to modify**	*Brushless*	*Range: 1 to 200 seconds, OFF* *Step 1*

FUNCTION:

If the SPM does not properly complete its starting sequence in the setpoint time, the SPM will trip and display an in-complete sequence condition.

COLLECTOR-RING: The time setting may be set to a value between 1 and 100 seconds, but not less than the FCX delay setpoint.

BRUSHLESS: The time setting may be set to a value between 1 and 200 seconds, but not less than the sum of the FAR delay setpoint and the FCX delay setpoint.

MOTOR TYPE:

Collector-Ring or Brushless

5.3.1 DESCRIPTION

The following parameters can be adjusted while the motor is running. See Section 7.5, Regulator Tune Up Instructions.

5.3.2 POWER FACTOR REGULATOR

REG PF: 0.00 ENTER to modify	*Range: –0.90 to 1.00, OFF* *Step: 0.01*

FUNCTION:

The SPM is capable of providing a Closed-loop PF Regulator with a very fast response. The regulator may be set up to regulate motor power factor in a range between 0.9 lagging to 1.0 (unity) to 0.0 leading power factor. This setpoint determines at what power factor the regulator will operate. The regulator may be disabled in order to output the floor value (see **FLOOR VOLTS** parameter) by entering OFF. This enables the operator to set up base-field amperes, then the regulator power factor may be returned to its normal setting and the regulator will function normally.

MOTOR TYPE:

Collector-Ring

5.3.3 REGULATOR GAIN

REG GAIN: 0.00 ENTER to modify	*Range: 1 to 100* *Step: 1*

FUNCTION:

Adjust this setpoint for optimum regulator performance.

MOTOR TYPE:

Collector-Ring

5.3.4 STABILITY

STABILITY: 1 cyc ENTER to modify	*Range: 1 to 60 cycles* *Step: 1*

FUNCTION:

This setpoint determines the number of most recent regulator output calculations to be averaged in order to help compensate for instability. Regulator calculations are performed once every 100 milliseconds.

MOTOR TYPE:

Collector-Ring

NOTE:

This eliminates the need for an external RC lag compensation network.

5.3.5 REGULATOR OUTPUT LIMIT

REG OUTPUT: 1 V ENTER to modify

Range: 0 to 10 V
Step: 1
Dependent on the **FLOOR VOLTS** *setpoint.*

FUNCTION:

This setpoint is the upper limit of the range of the control signal output voltage. This value must match the input range of the separate variable excitation equipment.

MOTOR TYPE:

Collector-Ring

NOTE:

This value must be greater than or equal to the FLOOR VOLTS setpoint.

5.3.6 FLOOR VOLTS

FLOOR VOLTS: 0.0 ENTER to modify

Range: 0.0 to 10 V
Step: 0.1

FUNCTION:

The floor value is the minimum limit for output control signal voltage that is connected to the field-rectifier equipment. The value programmed here is the exact output voltage from the SPM. For example, if the floor is programmed at 1.5 the SPM will output 1.5-volts minimum.

MOTOR TYPE:

Collector-Ring

NOTE:

This value must be less than or equal to the REG OUTPUT setpoint.

APPLICATION:

Certain conditions of operation require a floor so that the motor power factor will not become unstable if the field cur-rent is drastically reduced.

When the floor overrides the regulator, the power factor moves in a more leading condition than the regulator setpoint. As the load and/or system force the motor power factor toward the lagging condition such that the power factor falls below the regulator setpoint, the regulator will once again take control and boost the field above the floor so that the power factor will not dip below the setpoint. The power factor regulator must be tuned during initial start-up. See section 6-6 for regulator tune up instructions.

5.4.1 MOTOR TYPE

MOTOR: Collr-Ring
ENTER to modify

Range: Collr-Ring, Brushless

FUNCTION:

The type of motor is selected here. Different setpoints are used for the two different motors and operation of the relay is altered. This configuration setpoint must be entered correctly.

5.4.2 LINE FREQUENCY

LINE FREQ: 60 Hz
ENTER to modify

Range: 50 Hz, 60 Hz

FUNCTION:

Enter line frequency here for system.

5.4.3 POWER FACTOR REFERENCE

PF REF: Internal
ENTER to modify

Range: Internal, External

FUNCTION:

Enter the source for the voltage reference for power factor calculations. See Section 2.4, Electrical installation for proper wiring details.

5.4.4 RTU ADDRESS

RTU ADDRESS: 1
ENTER to modify

Range: 1 to 254
Step: 1

FUNCTION:

Enter the Modbus slave address here which must be unique to all SPMs on the same communication link.

5.4.5 BAUD RATE

BAUD RATE: 19.2k
ENTER to modify

Range: 300, 600, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115k

FUNCTION:

This setpoint allows the user to select the desired baud rate.

5.4.6 PARITY

PARITY: None
ENTER to modify

Range: None, Odd, Even

FUNCTION:

Enter the type of parity necessary.

5.4.7 TURNAROUND

TURNAROUND: 5
ENTER to modify

Range: 0 to 1000 ms
Step: 1

FUNCTION:

Turnaround is the delay before the relay changes from transmit to receive or vice versa. This setpoint need not be adjusted unless operating on a very slow system.

5.4.8 STATUS MODE

STAT: read only
ENTER to modify

Range: read only, read/write

FUNCTION:

This setpoint allows the user to configure the parameters in the STATUS MODE such that they are read only or read/writeable.

5.4.9 PASSWORD

PASSWORD: 0000
ENTER to modify

Range: 0000 to 9999
Step: 1

FUNCTION:

This allows the user to program a new password other then the factory default to restrict access to programmable feature on the SPM.

5.5.1 FULL-SCALE EXCITER DC VOLTAGE

FS EXC VOLT **ENTER to modify**

Range: 0.60 to 1.50 V
Step: 0.01

FUNCTION:

Use this setpoint to fine-tune the metered DC exciter voltage, input to the SPM from the VDN. To calibrate the exciter voltage compare the reading on the SPM with the measured value of an external meter and adjust this setpoint as necessary. Note that this must be done while the motor is running, thus it is advisable that the EX FLD VOLTS setting be turned OFF until calibration is complete.

5.5.2 FULL-SCALE EXCITER DC AMPS

FS EXC AMPS **ENTER to modify**

Range: 0.60 to 1.50 A
Step: 0.01

FUNCTION:

Use this setpoint to fine tune the metered DC exciter current, input to the SPM from the calibration module and DCCT. Coarse adjustment should be made via the calibration module potentiometer. To calibrate the exciter amps compare the reading on the SPM with the measured value of an external meter and adjust this setpoint as necessary. Note that this must be done while the motor is running, thus it is advisable that the EX FLD AMPS setting be turned OFF until calibration is complete.

5.5.3 FULL-SCALE MOTOR AC AMPS

FS MTR AMPS **ENTER to modify**

Range: 0.60 to 1.50 A
Step: 0.01

FUNCTION:

Use this setpoint to fine tune the metered AC motor current, input to the SPM from the connected CT(s).

6.1.1 DESCRIPTION

PWR FACTOR:	1.00
DC AMPS:	0 A
DC VOLTS:	0 V
EXC FIELD:	0 Ω
AC AMPS:	0 A

The display auto-scrolls through actual values when the motor is running. The operator can use the scroll keys to view specific values.

FUNCTION:

PWR FACTOR: Displays the power factor of the motor. 1.00 is unity, positive values are leading and negative values are lagging.

DC AMPS: Displays the exciter/field current in DC Amps.

DC VOLTS: Displays the exciter/field voltage in DC Volts.

EXC FIELD: Displays the exciter field resistance in Ohms.

AC AMPS: Displays the motor phase current in AC Amps.

NOTE:

These values can only be seen when the motor is running.

6.2.1 MOTOR RUNNING HOURS

```
MOTOR HRS:    0
SELECT to modify
```

FUNCTION:

Displays accumulated motor running hours.

6.2.2 INCOMPLETE SEQUENCE TRIP COUNTER

```
ISP TRIP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of incomplete sequence trips.

6.2.3 FIELD LOSS TRIP COUNTER

```
FLP TRIP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of field loss trips.

6.2.4 PULL-OUT TRIP COUNTER

```
PO TRIP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of pull out trips.

6.2.5 RESYNCRONIZATION ATTEMPTS TRIP COUNTER

```
RESYNC CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated numbers of resynchronization attempts. Present when PF MODE is set to resync. Available only when motor is collector-ring type.

6.2.6 MISSING EXTERNAL PF VOLTAGE REFERENCE COUNTER

```
NO V TRP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of missing voltage trips. Present when PF REF is set to external.

6.2.7 CHECK EXCITER TRIP COUNTER

```
EXC TRP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of check exciter trips.

6.2.8 POWER FACTOR TRIP COUNTER

```
PF TRP CTR:     0
SELECT to modify
```

FUNCTION:

Accumulated number of power factor trips.

6.2.9 SQUIRREL CAGE TRIP COUNTER

```
SCP TRP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of squirrel cage trips.

6.2.10 FIELD OVERVOLTAGE TRIP COUNTER

```
FOT TRP CTR:    0
SELECT to modify
```

FUNCTION:

Accumulated number of field overtemperature trips.

7.1.1 INSPECTION

Inspect all wiring and verify that the connections are clean, tight, and there is adequate clearance for all devices. All external wiring from the controller must be made in strict accordance with the main connection diagram supplied with the controller.

While referring to the main connection diagram supplied with the controller, inspect the wiring to determine with certainty that the starting and field-discharge resistor is connected in the motor field-discharge circuit through the discharge (closed) contact of the field-applying contactor (FC).

While inspecting the field contactor, manually pick up the contactor and confirm that the normally-closed contactor pole opens after the two normally-open poles close. It is important that all three poles are closed momentarily (overlap) during contactor pick-up and drop out (closed transition contacts).

To clean the face of the SPM, wipe with a damp cloth and mild detergent.

7.1.2 SPM TEST CHECKS

After the wiring check is complete, the equipment may be energized but DO NOT START MOTOR. With control power on, carefully follow the procedures below.

CAUTION

DO NOT TOUCH ANY CONNECTION POINT AT THE REAR OF THE SPM. POTENTIALS UP TO 1000 V MAY BE PRESENT ACROSS INPUTS V_F+ AND V_F–.

a) STANDBY MODE

1. Apply control power ONLY (do NOT start the motor).
2. The unit should power up and indicate that it is performing its power-on self-test. When this test is successfully completed, the motor type is shown (collector-ring or brushless) and **SPM READY** should be blinking on the display. If not, then a problem exists with the microprocessor or a peripheral device.
3. Obtain a list of the factory programmed setpoints and review the SPM setpoints. See Section 5.2: SETPOINTS MENU on page 5–2 for information on setpoints.

b) TEST MODE

Built-in diagnostics ensure the unit is operational prior to start-up. The SPM is placed in **TEST MODE** as follows:

1. Press the GE key to enter the **STAT MODE** menu.
2. Press the GE key again to enter the **PROGRAMMING MODE** menu.
3. Press the GE key one more time to enter the **TEST MODE** menu.
4. Select the required test then press ENTER to begin testing. There are three tests to choose from: system test (**SYSTEM TEST**), squirrel cage protection test (**SC PROT TEST**), and synchronization and power factor test (**SYNC AND PF TEST**). When entering test mode, the SPM responds by opening (de-energizing) the TRIP relay contacts. When exiting test mode, the SPM responds by closing (energizing) the TRIP relay contacts.
    - **SYSTEM TEST**: The SPM performs a complete system test on internal memory, input-output devices, timers, and other system functions. The results are displayed as the test progresses. The test sequence will report any failures. If a failure persists after two or three attempts, the unit should be replaced. The SPM must be reset if the test fails.

      CAUTION

      DO NOT DEFEAT THE SPM MOTOR RESTART PROTECTION BY SWITCHING THE CONTROL POWER ON AND OFF. THIS ACTION RESETS THE STALL TIME COUNTERS AND DEFEATS MOTOR PROTECTION FROM FREQUENT RESTARTS.

7

- Squirrel Cage Protection Test (**SC PROT TEST**): An internal SCP test frequency is inserted into the SCP program. After a time delay corresponding to the **STALL TIME** setpoint, the display reads **SQL CAGE TRIP!**. Press any key to reset.
- Synchronization and Power Factor Test (**SYNC AND PF TEST**): An internal slip frequency is injected into the synchronizing circuitry and slowly glides downward (simulating an accelerating motor). When this frequency matches the **SYNC SLIP** setpoint, the display flashes **FIELD IS APPLIED** and the FAR relay picks up, followed by the FCX after the **FCX DELAY** time setpoint. Next, the SPM automatically tests the power factor circuitry by internally generating a test power factor signal. No operator interface is required to proceed from the synchronizing test to the power factor test. This signal slowly decreases until it dips below the **PF TRIP** setpoint. After the **PF DELAY** setpoint time, the display reads **PWR FACTOR TRIP!**. Press any key to reset the unit. If SPM is in the RESYNC mode, the SPM may attempt to re-synchronize. If it does, the **FIELD IS APPLIED** message is displayed momentarily before a power factor trip occurs.

5. To leave **TEST MODE**, press and release the GE key until **SPM READY** is displayed again.

BE SURE TO STOP THE MOTOR AND DE-ENERGIZE ALL POWER BEFORE CHANGING ANY LEADS.

7.1.3 START-UP DESCRIPTION

Closing the feeder to the controller unit provides power to the control circuits and to the SPM. Energizing the SPM causes the TRIP relay contacts (terminals TRP1–TRP2) to close and the SPM to display **SPM READY**. Refer to Figure 2–4: PANEL AND TERMINAL LAYOUT on page 2–5 for trip relay contact locations and Figure 2–3: TYPICAL WIRING DIAGRAM on page 2–4 for wiring details.

Pressing the START button picks up relay MX, which in turn energizes the coil of main contactor M. When M closes and applies AC power to the motor, induced field current flows through the field discharge resistor and an associated voltage drop appears across terminals V_F + and V_F –. The frequency of this induced field voltage decreases as the motor speed increases, and the speed sensing circuits of the SPM cause the FAR relay to close as the motor reaches the programmed slip value. When the FAR relay contacts (terminals FAR1–FAR2) close, the field contactor (FC) closes and applies excitation to the motor from the exciter.

After the programmed **FCX DELAY**, the FCX relay picks up and closes its contacts, allowing the customer's automatic loading circuits to be activated.

7.2.1 DISPLAY

The SPM uses the alphanumeric display to indicate the following information:

- programming prompts
- SPM trip explanations
- readout of the desired motor running parameters

The motor running parameters are displayed as follows.

- Before start, the SPM displays **SPM READY**.
- While starting, the power factor and line amperes are displayed.
- When the field contactor closes, the SPM momentarily displays **FIELD IS APPLIED** followed by the normal running display of line current, field current (if this option is furnished), and motor power factor. The “+” indicates leading power factor (motor generating reactive power) while "–" indicates lagging power factor (motor consuming reactive power). The unity (1.0) power factor display may have a "+" or "–" sign indicating that power factor is just slightly leading or lagging.
- Once the motor has synchronized, the SPM displays power factor, line current, field volts (if optioned), field current (if optioned), and field ohms (if optioned).

7.2.2 SPM MESSAGES

The SPM has a number of built-in messages that may appear during normal operation or if an error is detected. Errors may occur because the CPU detects a problem internal to the SPM. These messages are explained in detail below.

- **FIELD IS APPLIED**: This message appears when the SPM has closed the field contactor. It is displayed briefly and is a normal SPM function.
- **PWR FACTOR TRIP**: The motor has been operating below the power factor setpoint too long causing a trip.
- **CHECK EXCITER**: The field voltage is below the minimum entered in the field undervoltage setpoint. The exciter should be checked to determine that it is functioning properly. Also, the setpoint should be examined to see if it is set too high for the normal exciter output.
- **FIELD LOSS TRIP!**: The field current is less than the field current setpoint. The exciter should be checked for proper output and the field current setpoint should be checked.
- **MISSING VOLTAGE!**: The SPM is NOT receiving a power factor reference voltage input to terminals V_{1EXT} and V_{2EXT} and **PF REF** is set to **External**.
- **SQL CAGE TRIP!**: The SPM has tripped the motor off-line due to a squirrel cage protection trip. The motor must be allowed to cool for the amount of time displayed by the SPM.
- **PULL-OUT TRIP!**: A trip has been caused by motor line current exceeding 4 times the full load current setpoint for longer than the PF delay time.
- **INCOM SEQ TRIP!**: The SPM has tripped the motor due to an incomplete sequence fault. The source of the fault should be located before the motor is restarted.
- **PULL-OUT TRIP!**: The SPM has tripped the motor due to pull-out.
- **FIELD OVERTEMP!**: The SPM has tripped the motor due to overtemperature on the field windings.
- **FAIL TO RESYNC!**: The SPM has tripped the motor due to a failure to resynchronize.
- **START INHIBITED! Ready in xxx min.**: The SPM has tripped the motor and will not allow a restart attempt for *xxx* minutes.

- **RUN-TIME FAULT**: The CPU has calculated a series of values within a set time limit that are out of their valid ranges. Power must be cycled to the unit to correct this error.
- **ROM FAILURE**: A PROM checksum error occurred during self-test. Consult GE Multilin to correct this problem.
- **NOVRAM FAILURE**: After the SPM writes data to its non-volatile memory (E^2PROM), the CPU immediately reads back the last value and compares it to what should have been written. If the two values are not equal, the SPM displays this message. This generally indicates a problem with the CPU Board. The SPM should be replaced.
- **RAM FAILURE**: A RAM checksum error occurred during self-test. This error is sometimes cleared by cycling power through the unit. Otherwise, consult GE Multilin.
- **FPGA FAILURE**: The Field Programmable Gate Array has failed to configure during self-test. Power can be cycled to the unit in an attempt to clear this error. Otherwise, consult the GE Multilin.
- **CHECK MX & TRP CIRCUIT**: The motor is in a tripped state. Either the MX contacts are still open and the TRIP relay is de-energized, or the TRIP relay is energized but the internal circuitry to sense this has failed.
- **MX or TRP FAILURE**: The MX circuit or the TRIP relay circuit has failed.
- **COMM CARD FAILURE**: The communications card has failed or was not present during power up or **SYSTEM TEST**. A periodic display of this error occurs only if a communication card test was passed during power-up and subsequently fails during normal operation. Only for units with the communications option.
- **WDT CKT FAILURE**: The watchdog timer circuit has failed during self-test.
- **INCOMPLETE SETUP**: The internal configuration information (not user selectable) has been lost and the unit will not function. The SPM must be returned to GE Multilin for correction of this problem.
- **CALIBRATION REQD**: The SPM has lost the calibration information stored in its non-volatile memory. The unit must be returned to GE Multilin for correction of this problem.
- **FORCED WDT TRIP**: The TRIP relay has been told to de-energize but is still showing as energized. In this condition, the CPU forces a watchdog timer trip in an attempt to de-energize the TRIP relay.
- **See Users Manual**: Consult the user manual for correction.

NOTE

Press any key to clear a trip messages such as PWR FACTOR TRIP! or SQL CAGE TRIP!.

CAUTION

DO NOT DEFEAT THE MOTOR RESTART PROTECTION PROVIDED BY THE SPM BY SWITCHING THE CONTROL POWER ON AND OFF. THE ABOVE ACTION RESETS THE STALL TIME COUNTERS WHICH DEFEATS MOTOR PROTECTION FROM FREQUENT RESTARTS.

7.3.1 INSTRUCTIONS

Following these instructions will permit tune-up of the regulator during the initial start-up of the motor. Perform all start-up procedures in Section 7.1: START-UP PROCEDURE on page 7–1 before proceeding.

1. Enter the following initial values into the SPM (see Section 5.3: OPTIONAL POWER FACTOR REGULATION SETPOINTS on page 5–10 for additional information on these setpoints):

   REG PF = OFF
   STABILITY = 1 cyc
   REG GAIN = 10
   REG. OUTPUT = 10 V
   FLOOR = 5.0 V

   - Setting **REG PF = OFF** places **FLOOR** in control of the motor field. The power factor regulator is disabled.
   - **FLOOR = 5.0 V** is sufficiently high enough to not trip the motor due to underexcitation when started.

2. After the above values are stored in memory and **SPM READY** is displayed, start the motor (unloaded if possible) and allow it to synchronize. The display should indicate a leading (positive) power factor.

3. To facilitate regulator tune-up, the five power factor regulator parameters can be changed while the motor is running. These are the only parameters that can be changed while in the "tuning mode".

   To get in "tuning mode" while the motor is running, enter programming mode and scroll to the **REGULATOR TUNING** menu. Press the ENTER key to enter the menu.

4. Press ▽/△ until the **FLOOR VOLTS** setpoint is displayed. Adjust the motor field current for a desired minimum (typically between 80 to 100% of rated field current). Change the floor value to a value above or below the initial value of 5.0, depending on whether more or less field current is desired. The floor parameter is the output voltage across the PF regulator output terminals +N and –N.

   NOTE: This method of parameter entry can only be employed while the motor is running and only for the five power factor regulator parameters.

5. Once the desired minimum motor field current is obtained, press ENTER to deselect **FLOOR VOLTS**. Press ▽/△ until the **PF REG** setpoint appears. Program the desired power factor (typically between 0.8 and 1.0). The control of the motor field current should now be in control of the closed-loop power factor regulator. Press ENTER again to deselect the **PF REG** setpoint.

6. Reset the **REG OUTPUT** setpoint to the original factory setting. This setpoint has been chosen to match the input of the separate variable exciter.

7. The regulator gain setpoint can probably be left at 10. However, should instability (hunting) occur, or if more optimum response is desired, the gain may be increased or decreased as desired. Press ▽/△ until **REG GAIN** appears in the display and enter new setpoints (range 1 to 100) using the same procedure as for the **FLOOR** and **REG PF** setpoints. The optimum gain is the highest possible gain setting without power factor instability detectable by a fluctuating exciter output and power factor. If instability still occurs, then increase the value of the **STABILITY** setpoint as required to dampen the fluctuating power factor. These parameters are automatically stored in the E^2PROM when the motor is shut down.

NOTE: Do not attempt to regulate 1.0 power factor with an unloaded or lightly loaded machine. A synchronous machine running unloaded at or near unity power factor is inherently unstable and will probably be tripped from power factor protection. Adjust the **FLOOR** setpoint high enough to override the regulator and avoid the instability while allowing the PF to move near zero lead power factor.

Table 7–1: SPM TROUBLESHOOTING (Sheet 1 of 2)

SYMPTOM	POSSIBLE CAUSE	CORRECTIVE ACTION
The SPM READY message is not displayed at power-up (motor not running).	Control voltage missing.	Check control fuses in synchronous controller (on primary and secondary of control power secondary).
	Connection plug is missing.	Insert connection plug at bottom of cradle assembly (see Figure....)
	Drawout cradle not fully engaged	Check removable cradle assembly and confirm that the top and bottom rotating latches engage cradle and are positioned to engage connection to disconnecting sockets at rear of case.
	Wrong voltage is applied to the V_1 and V_2 terminals.	Control voltage must be in the range of 85 to 265 V AC.
	Display is frozen.	Drop control power momentarily to the SPM and reapply. Some portion of the display should be actively blinking. If not, the CPU is not functioning. Replace with a new SPM.
	Missing or improper motor-on, motor-off input to SPM	Add or correct the isolated normally closed interlock from the main contactor or relay operated with the main contactor. Interlock is to be placed across MX to MX1 interlocks. **NOTE**: This interlock must be open when the motor is engaged.
	SPM not properly programmed.	Call each program address and check setpoint data against the desired setpoints (usually listed in the controller elementary).
	If the exciter voltage option is supplied, exciter may not be energized	Correct the operation of the DC field exciter so it outputs DC.
	Relay in tripped condition.	Press any keyboard button to RESET.
	Internal connector cable loose.	Remove front panel and check ribbon connectors for tightness. Ensure connectors are not skewed or partially connected to pins.
	Wiring to terminal points on rear of unit are missing / loose.	Connect or tighten missing/loose wires to proper points on the rear of the unit.
Motor starts but will not synchronize (FC does not close)	Synchronizing slip set too low. Motor cannot accelerate to slip level.	Refer to the setpoint programming instructions (Chapter 5) and program a higher value of percent slip.
	FAR relay does not pick up (SPM flashes **FIELD IS APPLIED** but contactor does not close).	Check external FAR contact circuit wiring.
	Field discharge resistor (sometimes shipped separately) is not connected or incorrectly installed	Check the connection of the field discharge resistor and correct if necessary.
	Motor trying to accelerate excessive load	Unload or reduce load on motor shaft until FCX relay picks up.
	A motor restart is aborted by SCP operation (**SQL CAGE TRIP** displayed)	The motor is taking too long to start or the stall time or run time setpoint is set too low. Correct as necessary
	Wiring to terminal points are missing or loose.	Connect or tighten missing or loose wires to proper points on the rear of the SPM.

Table 7–1: SPM TROUBLESHOOTING (Sheet 2 of 2)

SYMPTOM	POSSIBLE CAUSE	CORRECTIVE ACTION
Motor starts and synchronizes but shuts down immediately upon application of excitation.	**TRIP PF** setting too high.	Reduce **TRIP PF** value (address 01) to no higher than –0.8.
	FCX DELAY setting too low.	Increase **FCX DELAY** setting to 3 seconds minimum.
	Current/voltage inputs are incorrectly wired or are from incorrect phases.	Check and correct wiring as required.
	No excitation voltage.	Check for available DC excitation voltage. If a rotating exciter driven by a motor shaft is used, the exciter field should be forced (rheo is shorted out) during acceleration to cause exciter to build up its output as quickly as possible.
	No excitation current, open circuit at motor field, brushes, or leads.	Correct discontinuity in field circuit.
	Wiring to terminal points is missing or loose.	Connect or tighten missing or loose wires to proper points on the rear of the unit.
Shutdown occurs during normal running (after successful synchronization)	Motor has pulled out of step from excessive overload (**PF TRIP** or **PULL-OUT TRIP** is displayed)	Check condition of load bearing and other mechanical situations at drives. Push any key to reset the SPM and restart.
	Loss of excitation	Check exciter, exciter fuse, and connections to field.
	Transient power factor change occurring during system power disturbance.	Increase **PF DELAY** setting.
	Motor is unloaded and power factor regulator reference setpoint at or near unity resulting in instability.	Increase **REG FLOOR** setpoint to override regulator to maintain stability during light-load condition.
	Wiring to terminal points on rear of unit missing or loose.	Connect or tighten missing or loose wires to proper terminal points on rear of unit.
Motor starts, applies DC to field and then immediately removes DC from field	Exciter voltage too low causing SPM to attempt resynchronization.	Adjust exciter transformer tap or exciter adjustment potentiometer to obtain higher exciter voltage output.
	Field contactor closing too soon. Motor cannot pull-in to step since slip too high.	Reset **SYNC SLIP** to lower value.
	Excessive shaft load greater than the motor's capability to pull into step.	Reduce load or unload motor during start. Apply load after motor has synchronized and stabilized.
	Wiring to terminal points on rear of unit missing or loose.	Connect or tighten missing or loose wires to proper terminal points on rear of unit.
Display frozen, garbled, incorrect, or unreadable	Loose electrical connections or CPU failure.	Momentarily interrupt control power to unit and then re-energize. If still displaying incorrectly, replace unit **OR** check ribbon connector between faceplate assemble and top of cradle. It must not be loose, shifted, or skewed.
	Contrast needs adjustment.	Open lower flip door on faceplate assembly and rotate the contrast adjustment to obtain clear display.

7.5.1 PROGRAMMING EXAMPLE

The following example uses the following motor data and should be referred to as the example progresses. The data is for a 400 hp 4000 V ring-type motor. We will assume that all of the optional features available with the SPM have been installed. The following pages show the keypresses made by the operator, the SPM display response, and comments concerning the programming operation. The **SPM READY** message should be displayed at the beginning of the operation. Refer to Chapter 7 for programming the SPM for brush-less motors.

Motor: 400 hp, PF = –0.8, 720 RPM, 4000 V.
Induced field current: 0% SPD, 30 A; 95% SPD, 17 A.
Recommended field discharge resistance: 21 Ω
Allowable stall time: 7 seconds
50 percent run time: 11 seconds.

NOTE

The induced field voltage (product of induced field in amperes and discharge resistance in ohms) must fall between 200 and 1000 V at both zero and 95% speed. For this example:

21 Ω × 30 A = 630 V (zero speed check)
21 Ω × 17 A = 357 V (95% speed check)

The criterion is thus met for this example.

If induced field voltage is greater than 1000 volts, contact the factory

Table 7–2: PROGRAMMING EXAMPLE (Sheet 1 of 4)

KEYPRESS	DISPLAY	COMMENTS
None	Coil-Ring Motor SPM READY	Ready-mode display
	STAT MODE SCROLL for menus	Enter STAT mode on the way to PROGRAMMING MODE
	PROGRAMMING MODE SCROLL passwords	In PROGRAMMING MODE - must now enter the password
	PASSWORD: 0000 ENTER to verify	Use SCROLL keys to enter password and then press ENTER to verify the password
ENTER	CONFIGURATIONS? ENTER for menus	First menu after password entry is CONFIGURATIONS menu - must scroll past it to get to SETPOINTS menu
	SETPOINTS? ENTER for menus	Press SELECT/ENTER key to enter setpoint menus
ENTER	PF TRIP: –0.80 ENTER to modify	First setpoint is PF TRIP. SCROLL Key(s) to select value of -0.85 and then SELECT/ENTER key to accept new value.
, ENTER	PF TRIP: –0.85 ENTER to modify	Change existing value of PF TRIP to new –0.85 value.

Table 7–2: PROGRAMMING EXAMPLE (Sheet 2 of 4)

KEYPRESS	DISPLAY	COMMENTS
▽, ENTER	PF DELAY: 10.0 s ENTER to modify	Select the setpoint. Use the scroll key(s) to select value of 5.0 seconds and then ENTER to accept new value
▽, ENTER	PF DELAY: 5.0 s ENTER to modify	Change the existing value of PF DELAY to 5.0
▽	PF SUPP: 6% FLC ENTER to modify	This value will remain as is.
▽, ENTER	PF MODE: ridethru ENTER to modify	Select the setpoint. Use the scroll keys to move to the PF MODE setpoint and then ENTER to select the setpoint.
▽, ENTER	PF MODE: resync SCROLL to change	Change the existing value of PF MODE to resync. Use the scroll keys to select value of resync and then ENTER to accept new value.
▽	FCX DELAY: 1 s ENTER to modify	Press the scroll down key to move to the FCX delay setpoint. This value will remain as is.
▽, ENTER	AC CT RTG: 10/5 ENTER to modify	SCROLL DOWN key to move to the AC CT RTG setpoint and then SELECT/ENTER key to select the setpoint.
△, ENTER	AC CT RTG: 100/5 SCROLL to change	Change the existing value of AC CT RTG to 100. SCROLL Key(s) to select the value of 100 then SELECT/ENTER key to accept new value.
▽, ENTER	FL AMPS: 10 ENTER to modify	SCROLL DOWN key to move to the FL AMPS setpoint and then SELECT/ENTER key to select the setpoint
△, ENTER	FL AMPS: 58 SCROLL to change	Changes existing value of FL AMPS to 56. SCROLL Key(s) to select value of 58 and then SELECT/ENTER key to accept new value
▽, ENTER	LR AMPS: 116 ENTER to modify	SCROLL DOWN key to move to the LR AMPS setpoint and then SELECT/ENTER to select the setpoint
△, ENTER	LR AMPS: 226 SCROLL to change	Change the existing value of LR AMPS to 226. SCROLL Key(s) to select value of 226 and then SELECT/ENTER key to accept new value
▽, ENTER	SYNC SLIP: 0.5% ENTER to modify	SCROLL DOWN key to the SYNC SLIP set-point and then SELECT/ENTER key to select the setpoint
△, ENTER	SYNC SLIP: 4.0% SCROLL to change	Change the existing value of SYNC SLIP to 4.0%. SCROLL Key(s) to select value of 4% and then SELECT/ENTER key to accept new value

Table 7–2: PROGRAMMING EXAMPLE (Sheet 3 of 4)

KEYPRESS	DISPLAY	COMMENTS
▽, ENTER	STALL TIME: 40 s ENTER to modify	SCROLL DOWN key to move to the STALL TIME setpoint then SELECT/ENTER to select the setpoint
▽, ENTER	STALL TIME: 7 s SCROLL to change	Change the existing value of STALL TIME to 7 seconds. SCROLL Key(s) to select value of 7s and then SELECT/ENTER key to accept new value
▽, ENTER	RUNTIME: 3.00 x ST ENTER to modify	SCROLL DOWN key to move to the RUNTIME setpoint then SELECT/ENTER to select the setpoint
▽, ENTER	RUNTIME: 1.46 x ST SCROLL to change	Change the existing value of RUNTIME to 1.46 times the stall time. SCROLL Key(s) to select value of 1.46 and then SELECT/ENTER key to accept new value
▽, ENTER	DC CT PRIM: 20 A ENTER to modify	SCROLL DOWN key to move to the DC CT PRIM setpoint then SELECT/ENTER to select the setpoint
△, ENTER	DC CT PRIM: 100 A SCROLL to change	Change the existing value of DC CT PRIM to 100A. SCROLL Key(s) to select value of 100 and then SELECT/ENTER key to accept new value.
▽	HIGH FIELD: 10.0 Ω ENTER to modify	SCROLL DOWN key to move to the HIGH FIELD setpoint. This value will remain as is.
▽, ENTER	FIELD AMPS: OFF ENTER to modify	SCROLL DOWN key to move to the FIELD AMPS setpoint then SELECT/ENTER to select the setpoint.
△, ENTER	FIELD AMPS: 45 SCROLL to change	Change the existing value of FIELD AMPS to 45. SCROLL Key(s) to select value of 45 and then SELECT/ENTER key to accept new value
▽, ENTER	FIELD VOLTS: 25 ENTER to modify	SCROLL DOWN key to move to the FIELD VOLTS setpoint then SELECT/ENTER to select the setpoint
△, ENTER	FIELD VOLTS: 125 SCROLL to change	Change the existing value of FIELD VOLTS to 125. SCROLL Key(s) to select value of 125 and then SELECT/ENTER key to accept new value.
▽, ENTER	INC SEQ DLY: 100 s ENTER to modify	SCROLL DOWN key to move to INC SEQ DLY setpoint then SELECT/ENTER to select the setpoint
▽, ENTER	INC SEQ DLY: 15 s SCROLL to change	Change the existing value of INC SEQ DLY to 15 seconds. SCROLL Key(s) to select value of 15 and then SELECT/ENTER key to accept new value.
▽, ENTER	REG PF: OFF ENTER to modify	SCROLL DOWN key to move to REG PF set-point then SELECT/ENTER to select the setpoint

Table 7–2: PROGRAMMING EXAMPLE (Sheet 4 of 4)

KEYPRESS	DISPLAY	COMMENTS
▲, ENTER	REG PF: 0.85 SCROLL to change	Change the existing value of REG PF to 0.85 leading. SCROLL Key(s) to select value of 0.85 and then SELECT/ENTER key to accept new value
▼	REG GAIN: 10 ENTER to modify	SCROLL DOWN key to move to REG GAIN setpoint. This setpoint is correct
▼	STABILITY: 1 cyc ENTER to modify	SCROLL DOWN key to move to STABILITY setpoint. This setpoint is correct
▼, ENTER	REG OUTPUT: 5 V ENTER to modify	SCROLL DOWN key to move to REG OUTPUT setpoint then SELECT/ENTER to select the setpoint.
▲, ENTER	REG OUTPUT: 10 V SCROLL to change	Change the existing value of REG PF to 10V. SCROLL Key(s) to select value of 10 and then SELECT/ENTER key to accept new value
▼, ENTER	FLOOR VOLTS: 0.00 ENTER to modify	SCROLL DOWN key to move to FLOOR VOLTS setpoint then SELECT/ENTER to select the setpoint.
▲, ENTER	FLOOR VOLTS: 5.00 SCROLL to change	Change the existing value of FLOOR VOLTS to 5.00. SCROLL Key(s) to select value of 5.00 and then SELECT/ENTER key to accept new value
GE	SETPOINTS? ENTER for menus	Exit out to SETPOINTS menu.
GE	SAVE CHANGES? ENTER to save...	Save setpoint changes.
ENTER	PROGRAMMING MODE SCROLL PASSWORD	Exit out to PROGRAMMING MODE menu
GE	TEST MODE SCROLL for tests	Exit out to TEST MODE menu
GE	Coil-Ring Motor SPM READY	Ready-mode display

7.6.1 DOs

1. Always connect the MX input up to an auxiliary 'b' contact from the motor contactor.

It is this contact that indicates to the SPM that the motor has been started or stopped. Protection and synchronization routines will not run properly if this input is not connected.

2. Ensure that all ground connections are made to the ground bus.

Grounding to doors or other painted surfaces may cause the noise immunity of the SPM to be reduced.

7.6.2 DON'Ts

1. Don't use the VDN module that was supplied with the old version MSPM (C0192) with the SPM.

The VDN module has changed and is incompatible. Damage or miss operation will occur if used.

2. Don't use a 1A secondary CT with the SPM

The SPM has been designed to work with 5A CTs only.

3. Don't mount the SPM display remotely.

The display must be mounted to the case when in operation. Noise problems may result if it is wired remotely.

4. Do not enable the FIELD VOLTS setpoint if the exciter is not powered up prior to starting the motor.

Field volts are monitored prior to starting and while the motor is running. A missing voltage start block will be issued if the SPM detects field volts less than the setpoint level while the motor is stopped and prevent starting of the motor.

1. Is the SPM a drop in replacement for the μSPM?

Functionally the SPM is a replacement for the older μSPM. The following points detail the differences between the SPM and the μSPM when retrofitting:

- The SPM cutout size smaller. An MPSPM retrofit panel can be ordered to retrofit the SPM into existing μSPM cutouts.
- Terminal numbers have changed but terminal labels and functions remain the same.
- The VDN module has changed and the SPM must be used with the new VDN supplied with it. The CM and DCCT are the same and can be used with the SPM or μSPM.
- All μSPM options except for PF Regulation (which can be ordered) are standard on the SPM.

2. What do I do if I forget my password?

If a non-0000 password has been entered for access to programming it must be entered to gain write access. If this password has been forgotten it may be recovered in the following manner:

1. Using the GE key go to the programming section.
2. Press the scroll up key.
3. When asked to enter the password, press and hold the scroll up key and then without releasing press and hold the enter key. While both keys are held and encrypted password will appear on the screen.
4. Record this password and contact the GE Multilin service center. They can decode the password for you.

3. What causes a run time fault?

A run time fault is initiated by the SPM when it calculates a metered value beyond its acceptable range. The two most common causes of this are:

- SPM measures a starting current higher than the programmed locked rotor current.

  Solution: program **LR AMPS** with maximum current value seen during a start.
- SPM measures the field ohms to be beyond range of DCCT.

  Solution: Turn the **HIGH FIELD** setpoint **OFF** and check calibration of DCCT and CM.

4. What is the cause of an incomplete sequence trip and how do I correct it?

An incomplete sequence trip is issued if the motor fails to synchronize in a set amount of time. Check the following points:

- Has the **INC SEQ DLY** been set long enough to allow the motor to start?
- Check the VDN wiring VDN. Is it properly connected across the field discharge resistor (ring type motors)?
- Has the **SYNC SLIP** setting been set to the correct level (ring type motors)?
- Measure the frequency at the V_F +/– terminals and ensure it falls below the programmed slip level. If not, check wiring, grounding, and the motor.

5. What is the SPM internal CT burden?

The CT burden is 16 mΩ or 0.4 VA at 1 × CT.

6. What is the power consumption to the SPM?

The SPM draws 10 VA nominal at 120 V AC.

7. Why do I get a long lockout time if my motor trips or fails to start?

The lockout time is variable. It is calculated to protect the motor from overheating and subsequent break-down of the amortisseur winding. This heating is caused during motor acceleration. If the lockout time is too long it can be decreased by selecting a higher RUNTIME curve setting or by setting a longer STALL TIME. Note: If either of these changes are done make sure that you have not gone beyond the motor manufacturer's specifications. To avoid lockouts entirely, tripping or stopping the motor during or shortly after a start should be avoided where possible.

FIRMWARE REVISION: 109.000

- Original firmware revision for BETA test units delivered from GE Multilin in Plainville.

FIRMWARE REVISION: 151.000

- All features made standard except power factor regulation
- Check exciter field disabled while starting
- Off settings added to exciter/field voltage, current and resistance elements.
- Transient immunity improved via disabling unused inputs to processor.

FIRMWARE REVISION: 152.000

- Display now refreshed every 30 seconds

FIRMWARE REVISION: 200.000

- Modbus communications added
- Self-test changed
- Off settings made uniform

FIRMWARE REVISION: 201.000

- FAR relay not being released upon motor stopping error corrected

FIRMWARE REVISION: 202.000

- Removed runtime error on starts when measured locked rotor exceeds programmed locked rotor
- Improved communications integrated

FIRMWARE REVISION: 203.000

- The incomplete sequence function will not operate when the motor type is selected as *Collector Ring*. Instead a SQUIRREL CAGE TRIP is received.

FIRMWARE REVISION: 210.000

- Field Amps Loss delay added
- Field Volts Loss delay added

8.1.1 GE MULTILIN VDN

The VDN is provided to connect the SPM to field and/or exciter voltages. The VDN is included as a standard accessory.

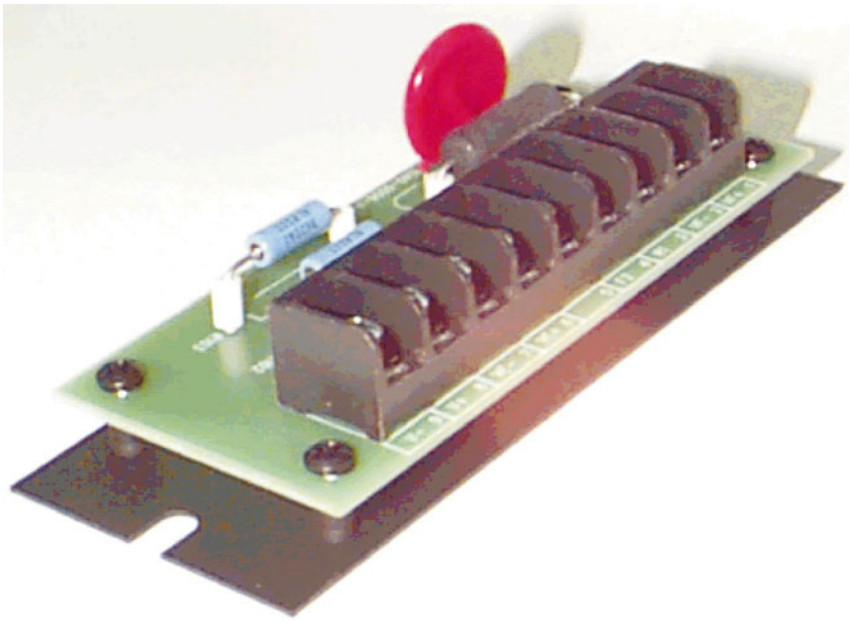


Figure 8–1: GE MULTILIN VOLTAGE DIVIDER NETWORK

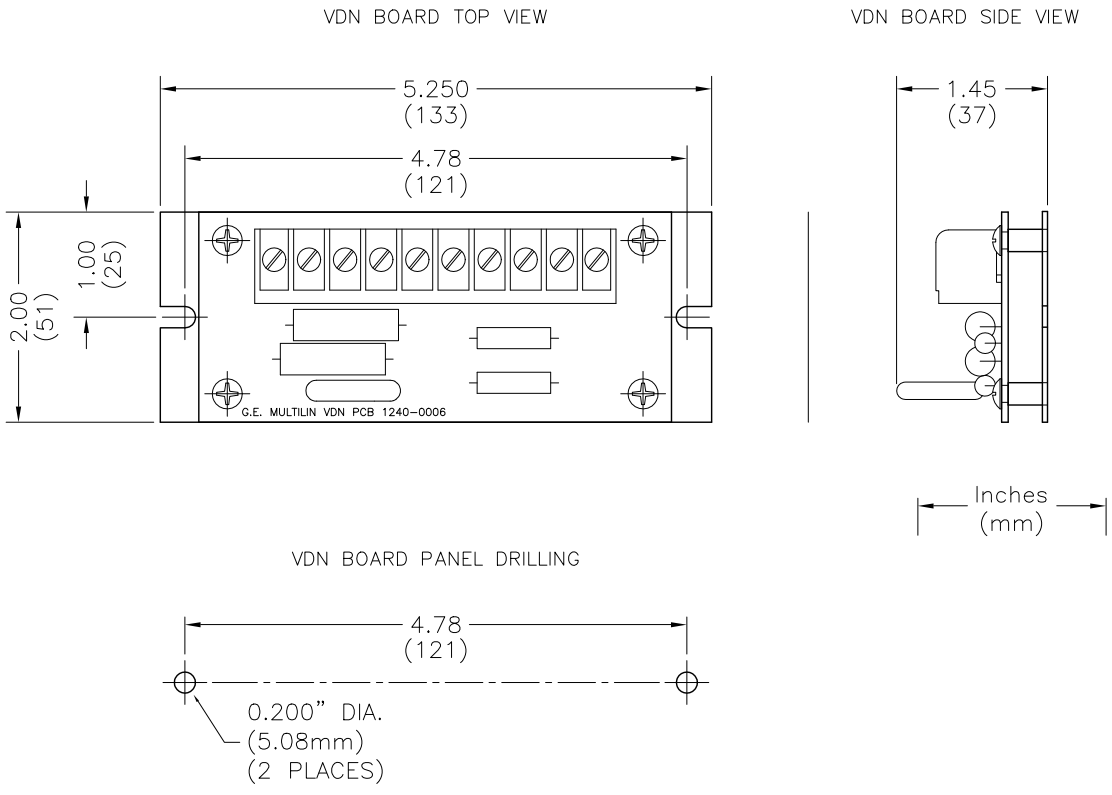


Figure 8–2: GE MULTILIN VDN DIMENSIONS

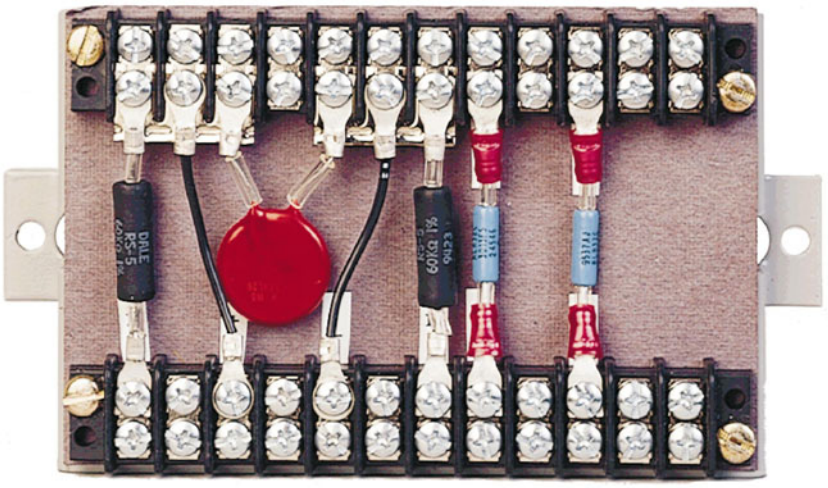


Figure 8–3: GE MEBANE VOLTAGE DIVIDER NETWORK

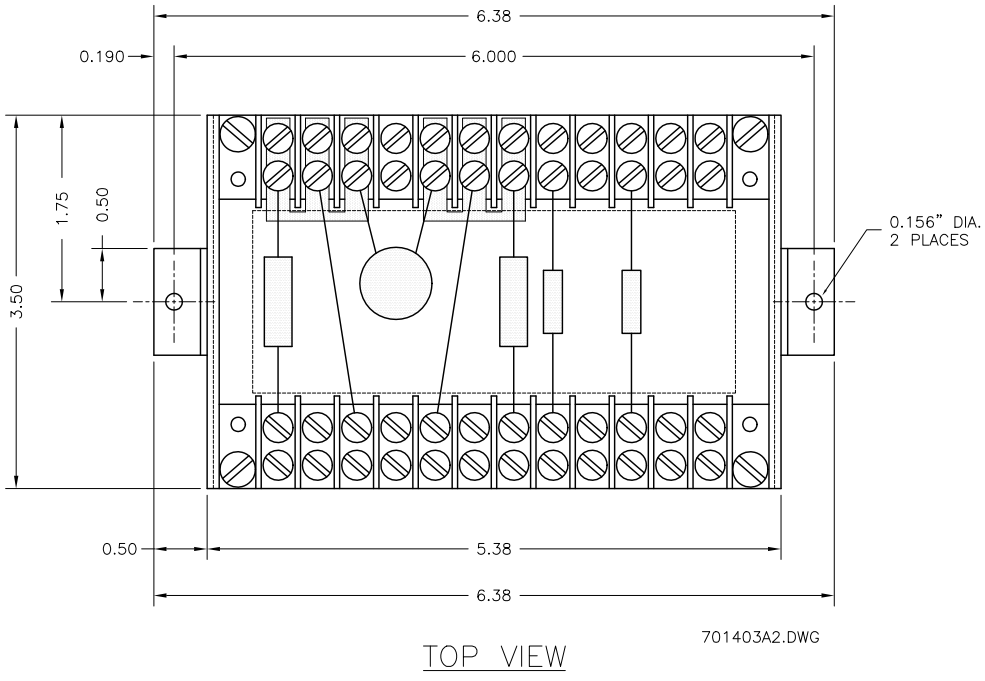


Figure 8–4: GE MEBANE VDN DIMENSIONS

8.2.1 GE MULTILIN MODULE

The Calibration Module (CM) provides the proper AC excitation voltage to the DCCT and provides a calibration adjustment to obtain a proper field amperes reading. This calibration is performed with a potentiometer.

The Calibration Module is required to utilize field current and/or field overtemperature features. It is included in the optional PG2SPM or PG4SPM accessory packages.

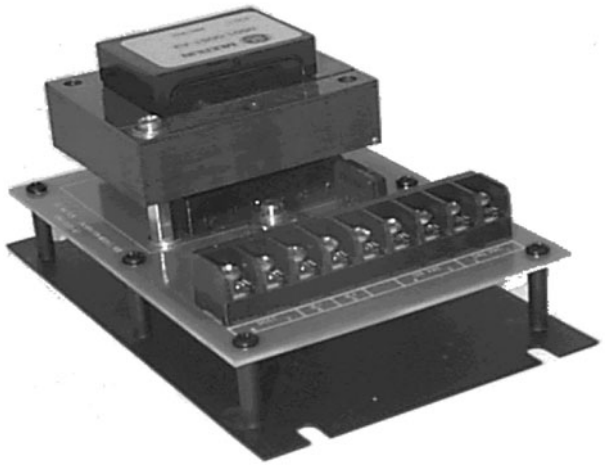


Figure 8–5: GE MULTILIN CALIBRATION MODULE

NOTE

The Calibration Module for DCCT5 (GE part#1740-0008) shall not be used with DCCT2.

WARNING

The Calibration Module for DCCT2 (GE part#1740-0005) if used with DCCT5 for DC currents higher than 200A, may not perform as expected and can damage the calibration module.

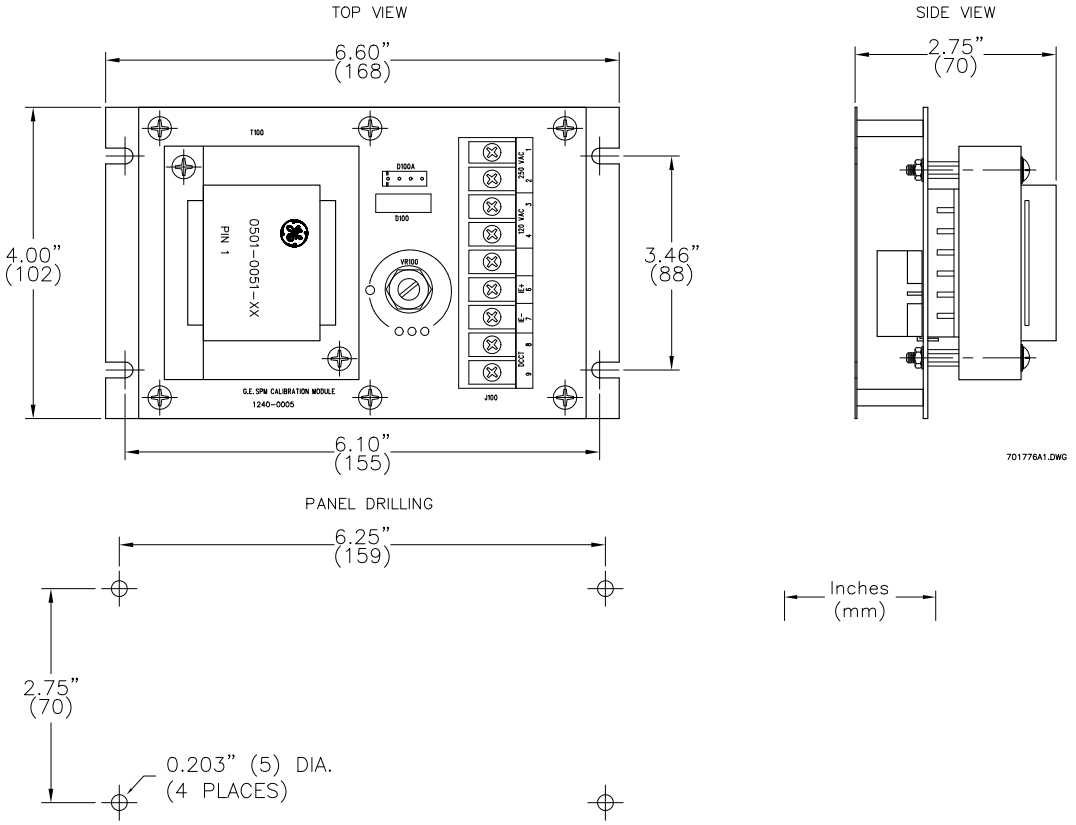


Figure 8–6: GE MULTILIN CM PHYSICAL DIMENSIONS

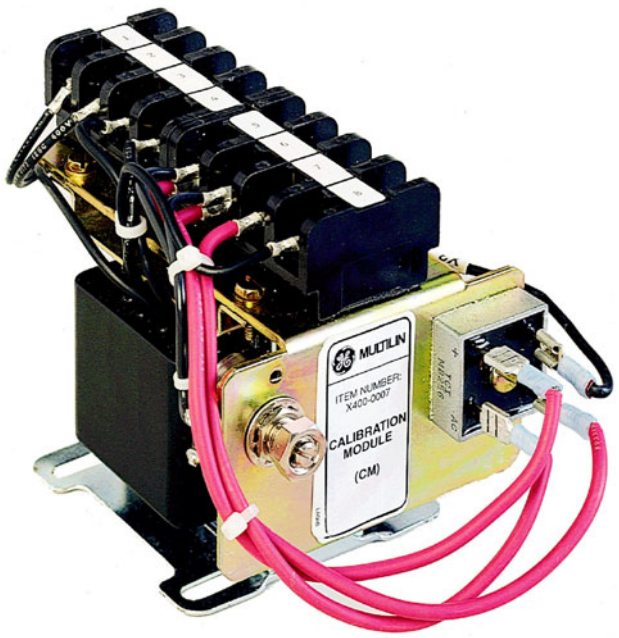


Figure 8–7: GE MEBANE CALIBRATION MODULE

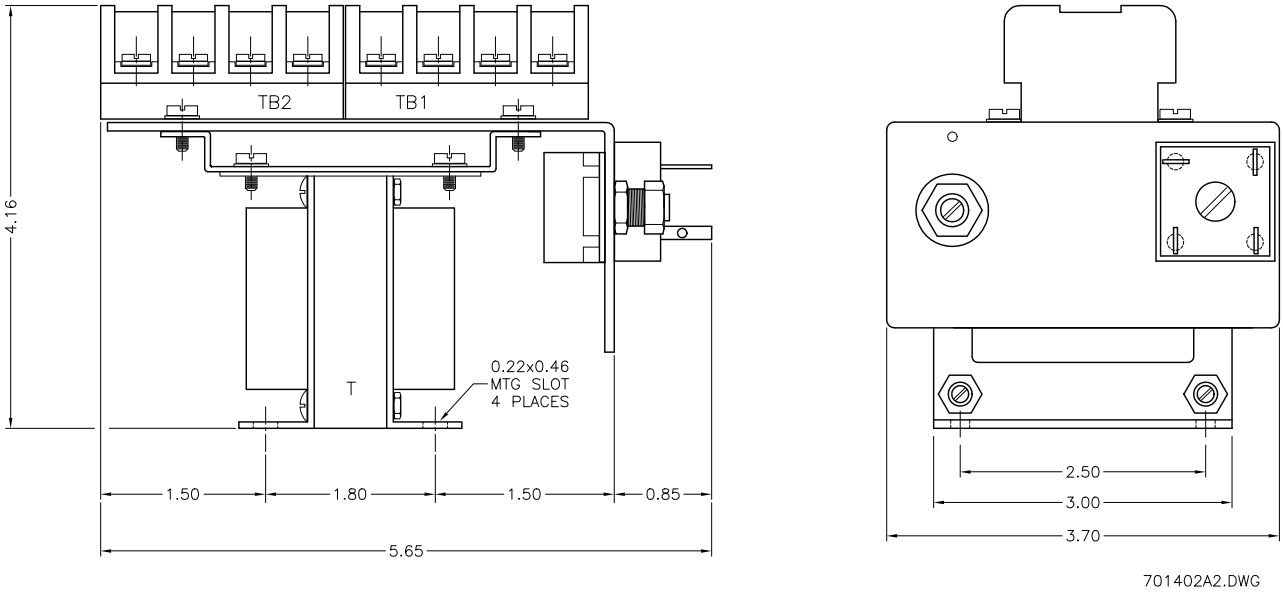


Figure 8–8: GE MEBANE CM PHYSICAL DIMENSIONS

8.3.1 DESCRIPTION

The standard DCCT primary has a rated 200 A primary and a 50 mA rated secondary (4000:1 ratio). DCCT terminals connect to CM points (7) and (8) (polarity not important). Multiple turns of field able through the DCCT window may be required to obtain the proper effective CT ratio. The DCCT is required to utilize field current and/or field overtemperature features. It is available in the optional PG2SPM or PG4SPM accessory packages.

Figure 8–9: DC CURRENT TRANSFORMER

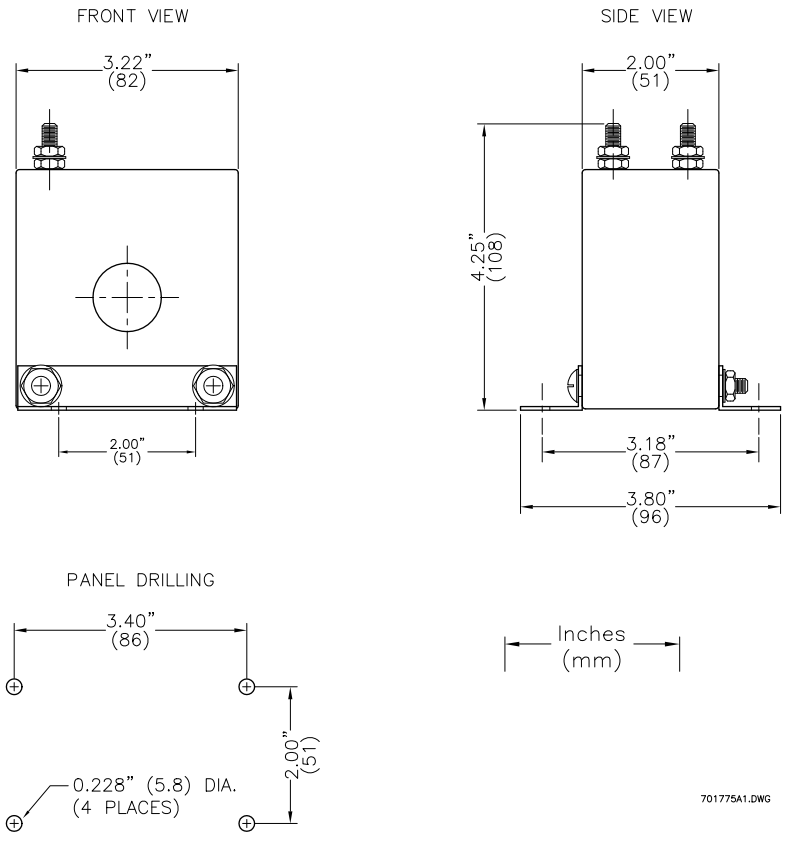


Figure 8–10: DCCT PHYSICAL DIMENSIONS

9.1.1 MODBUS PROTOCOL

The SPM supports a subset of the AEG Modicon Modbus RTU serial communication standard using a 2-wire RS485 interface. The following commands are supported (Modbus names are in brackets):

- 03: Read Setpoints and Actual Values (read holding registers)
- 04: Read Setpoints and Actual Values (read input registers)
- 05: Execute Operation (force single coil; coil number 1 emulates the relay reset function)
- 06: Store Single Setpoint (preset single register)
- 07: Read Device Status (read exception status)
- 16: Store Multiple Setpoints (preset multiple registers)

9.1.2 PERFORMANCE REQUIREMENTS

- Baud rates: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200.
- Turn around time less than 50 ms from receipt of last character to transmission of first character.
- Two-wire RS485 connection.
- Data frame fixed at 1 start, 8 data and 1 stop bit.

9.1.3 SETPOINTS

The following setpoints are required to set up the Modbus communications port:

CONFIGURATIONS \ **RTU ADDRESS**:Range 1 to 254. Set to the SPM address (must be unique for each relay on the channel).

CONFIGURATIONS \ **BAUD RATE**: Set from 300 to 115k baud

CONFIGURATIONS \ **PARITY**: Set to none, even or odd, depending on configuration

CONFIGURATIONS \ **TURNAROUND**: Enter the minimum Modbus turnaround time, 0 to 1000 ms

9.1.4 EXECUTE OPERATION COMMAND CODES (COIL NUMBERS)

The following table lists the coil numbers, which may be used in the Modbus "force coil" command.

Table 9–1: EXECUTE OPERATION CODES

COIL NUMBER	FUNCTION
0001h	Simulate a keypad reset (i.e., reset a trip after the condition has cleared)
0101h	Force the FAR into the energized state
0111h	Force the FAR into the de-energized state
0121h	Un-force the FAR, reverting it to program control
0102h	Force the FCX relay into the energized state
0112h	Force the FCX relay into the de-energized state
0122h	Un-force the FCX relay, reverting it to program control
0103h	Force the TRP relay into the energized state
0113h	Force the TRP relay into the de-energized state
0123h	Un-force the TRP relay, reverting it to program control

Table 9–2: MODBUS MEMORY MAP (Sheet 1 of 5)

GROUP	ADDR (hex)	DESCRIPTION	RANGE	STEP VALUE	UNITS	FORMAT CODE	FACTORY DEFAULT
Product ID (Input registers at addresses 0000 to 007F)							
PRODUCT ID	0000	GE Product Device Code	N/A	N/A	N/A	U16	40
	0001	Product Hardware Revision	1 to 26	1	N/A	Alpha	N/A
	0002	Product Software Revision	N/A	N/A	N/A	Revcode	N/A
	0003	Product Modification Number	0 to 999	1	N/A	U16	N/A
	0004	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	007F	Reserved					
Actual Values (Input registers at addresses 0200 to 0FFF)							
MOTOR STATUS	0200	Motor Status				Motorstatus	N/A
	0201	Estimated Time to Trip for Stall				U16	N/A
	0202	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	020F	Reserved					
TRIP DATA	0210	Cause of Trip				Tripcause	N/A
	0211	Lockout Time				U16	N/A
	0212	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	021F	Reserved					
LINE CURRENT	0220	Instantaneous Line Current				U16	N/A
	0221	Filtered Line Current				U16	N/A
	0222	Reserved					
	0223	Reserved					
	0224	Reserved					
LINE VOLTAGE	0225	Instantaneous Motor Voltage				U16	N/A
	0226	Filtered Motor Voltage				U16	N/A
	0227	Reserved					
	0228	Reserved					
	0229	Reserved					

* Range for collector-ring motors.

** Range for brushless motors.

1. The access password must be written correctly before any setpoints can be written via Modbus. The password is initially the same as the default password, but the two passwords are stored separately, so the keyboard can not be used to change the communications password and vice-versa.
2. The allowable range of FLA is as follows: the minimum full load amps value is 2/5 times the CT ratio; the maximum is equal to the CT ratio.
3. The locked rotor current is range dependent on the FLA setpoint: the minimum is twice the full load amps and the maximum value is 12 times the FLA.
4. REGULATOR OUTPUT must be greater than or equal to FLOOR VOLTS, likewise FLOOR VOLTS must be less than or equal to REGULATOR OUTPUT.

Table 9–2: MODBUS MEMORY MAP (Sheet 2 of 5)

GROUP	ADDR (hex)	DESCRIPTION	RANGE	STEP VALUE	UNITS	FORMAT CODE	FACTORY DEFAULT
POWER FACTOR	022A	Instantaneous Power Factor				Pwrfactor	N/A
	022B	Filtered Power Factor				Pwrfactor	N/A
	022C	Instantaneous Phase Angle				U16	N/A
	022D	Filtered Phase Angle				U16	N/A
	022E	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	0231	Reserved					
EXCITER CURRENT	0232	Instantaneous Exciter Current				U16	N/A
	0233	Filtered Exciter Current				U16	N/A
	0234	Reserved					
	0235	Reserved					
	0236	Reserved					
EXCITER VOLTAGE	0237	Instantaneous Exciter Voltage				U16	N/A
	0238	Filtered Exciter Voltage				U16	N/A
	0239	Reserved					
	023A	Reserved					
	023B	Reserved					
FIELD OHMS	023C	Instantaneous Field Ohms				U16	N/A
	023D	Filtered Field Ohms				U16	N/A
	023E	Reserved					
	023F	Reserved					
	0240	Reserved					
INDUCED FIELD	0241	Field Voltage Frequency	0.00 to 99.99			2decU16	N/A
	0242	Percentage Slip	0.0 to 100.0			1decU16	N/A
	0243	Reserved					
	0244	Reserved					
	0245	Reserved					
OUTPUT RELAYS	0246	TRIP Relay Status				Relaystate	N/A
	0247	FAR Relay Status				Relaystate	N/A
	0248	FCX Relay Status				Relaystate	N/A
	0249	Reserved					
	024A	Reserved					
	024B	Reserved					

* Range for collector-ring motors.
** Range for brushless motors.
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Table 9–2: MODBUS MEMORY MAP (Sheet 3 of 5)

GROUP	ADDR (hex)	DESCRIPTION	RANGE	STEP VALUE	UNITS	FORMAT CODE	FACTORY DEFAULT
DIGITAL INPUTS	024C	MX Status				Switchstate	N/A
	024D	NX Status				Switchstate	N/A
	024E	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	0254	Reserved					
STATISTICS (can be written as holding registers)	0255	Motor Running Hours				U16	N/A
	0256	Incomplete Sequence Trip Counter				U16	N/A
	0257	Field Loss Trip Counter				U16	N/A
	0258	Pull Out Trip Counter				U16	N/A
	0259	Resynchronization Trip Counter				U16	N/A
	025A	Missing External PF Voltage Reference				U16	N/A
	025B	Check Exciter Trip Counter				U16	N/A
	025C	Power Factor Trip Counter				U16	N/A
	025D	Squirrel Cage Trip Counter				U16	N/A
	025E	Field Overtemperature Trip Counter				U16	N/A
	025F	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	0FFF	Reserved					
Setpoints (Holding registers at addresses 1000 to 2FFF)							
SYSTEM CONFIGURATION	1000	ACCESS PASSWORD [1]	0 to 9999	1	-	U16	0000
	1001	MOTOR TYPE	0 or 1	-	-	Motortype	0
	1002	LINE FREQUENCY	0 or 1	-	Hz	Linefreq	0
	1003	POWER FACTOR REFERENCE	0 or 1	-	-	PFreg	1
	1004	RTU ADDRESS	1 to 254	1	-	U16	1
	1005	BAUD RATE	0 to 9	1	baud	Baudrate	6
	1006	RS485 PARITY	0 to 2	1		Parity	0
	1007	RS485 MIN. TURNAROUND TIME	0	1000	ms	U16	5
	1008	STATISTICS MODE	0 or 1	1	-	Startmode	1
	1009	NEW PASSWORD	0 to 9999	1	-	U16	4985
	1010	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	104F	Reserved					

* Range for collector-ring motors.

** Range for brushless motors.

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Table 9–2: MODBUS MEMORY MAP (Sheet 4 of 5)

GROUP	ADDR (hex)	DESCRIPTION	RANGE	STEP VALUE	UNITS	FORMAT CODE	FACTORY DEFAULT
SYSTEM CALIBRATION	1050	FULL SCALE EXCITER DC VOLTAGE	0.6 to 1.5	0.01	-	U16	100
	1051	FULL SCALE EXCITER DC AMPS	0.6 to 1.5	0.01	-	U16	100
	1052	FULL SCALE MOTOR AC AMPS	0.6 to 1.5	0.01	-	U16	100
	1053	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	10FF	Reserved					
POWER FACTOR	1100	PF TRIP	–0.60 to 1.00	0.01	-	2decS16	60
	1101	PF DELAY	0.1 to 10.0	0.1	s	1decU16	50
	1102	PF SUPPRESSION	6 or 50	-	%FLC	U16	6
	1103	PF MODE	0 or 1			PFmode	0
	1104	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	110F	Reserved					
FIELD/LOAD APPLICATION	1110	FAR DELAY	0 to 90	1	s	U16	0
	1111	FCX DELAY	1 to 6 * 1 to 90 **	1	s	U16	1
	1112	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	111F	Reserved					
MOTOR / AC SYSTEM	1120	AC CT RATIO	5 to 2000	5	:5	U16	50
	1121	FULL LOAD AMPS	2 to 2000 [2]	1	A	U16	25
	1122	LOCKED ROTOR AMPS	4 to 24000 [3]	1	A	U16	200
	1123	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	112F	Reserved					
STARTING SETPOINTS	1130	SYNCHRONOUS SLIP	0.5 to 10.0	0.1	%	1decU16	50
	1131	STALL TIME	1 to 40	1	s	U16	10
	1132	RUN TIME	1.05, 1.46, 2.05, 3.00	-	× stall time	Runtime	3
	1133	INCOMPLETE SEQUENCE DELAY (max+1 = OFF)	1 to 100 or OFF * 1 to 200 or OFF **	1	s	U16	201
	1134	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	113F	Reserved					

* Range for collector-ring motors.

** Range for brushless motors.

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Table 9–2: MODBUS MEMORY MAP (Sheet 5 of 5)

GROUP	ADDR (hex)	DESCRIPTION	RANGE	STEP VALUE	UNITS	FORMAT CODE	FACTORY DEFAULT
DC SYSTEM	1140	DC CT PRIMARY	5 to 1000	1	A	U16	5
	1141	HIGH (EXCITER) FIELD (max+1 = OFF)	0.20 to 450.00 or OFF	0.01, 0.10, 1.00	Ω	2decU16	0
	1142	(EXCITER) FIELD AMPS (zero = OFF)	0.1 to 1000.0 or OFF	0.1 if <10A 1.0 if ≥10A	A	1decU16	0
	1143	(EXCITER) FIELD VOLTS (zero = OFF)	1 to 200 or OFF	1	V	U16	0
	1144	(EXCITER) FIELD AMPS DELAY	0.3 to 5.0	0.1	s	1decS16	0.3
	1145	(EXCITER) FIELD VOLTS DELAY	0.3 to 5.0	0.1	s	1decS16	0.3
	1146	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	114F	Reserved					
PF REGULATION	1150	PF REGULATION LEVEL (max+1 = OFF)	–0.90 to 1.00 / OFF	0.01	-	2decS16	111
	1151	REGULATOR GAIN	1 to 100	1	-	U16	1
	1152	STABILITY	1 to 60	1	-	U16	1
	1153	REGULATOR OUTPUT	0 to 10 [4]	1	V	U16	1
	1154	FLOOR VOLTS	0.0 to 10.0 [4]	0.1	V	1decU16	0
	1155	Reserved					
	↓	↓	↓	↓	↓	↓	↓
	115F	Reserved					

* Range for collector-ring motors.

** Range for brushless motors.

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Table 9–3: MEMORY MAP FORMAT CODES (Sheet 1 of 2)

CODE	ENUMERATION	VALUE	MEANING
1decS16	16-bit	Signed integer with 1 decimal place (i.e. 10 times the real value)	
1decU16	16-bit	Unsigned integer with 1 decimal place (i.e. 10 times the real value)	
2decS16	16-bit	Signed integer with 2 decimal places (i.e. 100 times the real value)	
2decU16	16-bit	Unsigned integer with 2 decimal places (i.e. 100 times the real value)	
Alpha	32-bit	An alphabetic letter	
		1	“A”
		2	“B”
		↓	↓
		26	“Z”
Baudrate	16-bit	0	300 baud
		1	600 baud
		2	1200 baud
		3	2400 baud
		4	4800 baud
		5	9600 baud
		6	19200 baud
		7	38400 baud
		8	57600 baud
		9	115200 baud
Enable	16-bit	0	Disable
		1	Enable
Linefreq	16-bit	0	60 Hz
		1	50 Hz
Motorstatus	16-bit	0	Off
		1	Starting
		2	Stabilizing
		3	Resynchronizing
		4	Running
Motortype	16-bit	0	Brushless
		1	Ring-type
PFmode	16-bit	0	Ride-thru
		1	Re-sync
Parity	16-bit	0	No Parity
		1	Even Parity
		2	Odd Parity
PFreg	16-bit	0	Internal
		1	External

Table 9–3: MEMORY MAP FORMAT CODES (Sheet 2 of 2)

CODE	ENUMERATION	VALUE	MEANING
Pwrfactor	16-bit	Signed integer with 2 decimal places (i.e. 100 times the real value). Negative numbers are lagging power factors; positive numbers are leading power factors.	
Relaystate	16-bit	0	De-energized
		1	Energized
Revcode	16-bit	Unsigned integer interpreted as 4 BCD digits. For example, revision 1234 would be 1234 hex or 4660 decimal	
Runtime	16-bit	0	1.05 × stall time
		1	1.46 × stall time
		2	2.05 × stall time
		3	3.00 × stall time
S16	16-bit	Signed integer	
Statmode	16-bit	0	Read-only
		1	Read-write
Switchstate	16-bit	0	Open
		1	Closed
Tripcause	16-bit	0	Squirrel-cage protection
		1	Power Factor
		2	Check exciter
		3	Missing voltage
		4	Fail to resync
		5	Pull-out
		6	Field loss
		7	Incomplete sequence protection
		8	Restart
		9	Field overtemperature
U16	16-bit	Unsigned integer	

10.1.1 DESCRIPTION

The purpose of this section is to demonstrate the procedures necessary to perform a complete functional test of all the SPM hardware while also testing firmware/hardware interaction in the process. Since the SPM is packaged in a drawout case, a demo case (metal carry case in which an SPM may be mounted) may be useful for creating a portable test set with a wiring harness for all of the I/O. Testing of the relay during commissioning using a primary injection test set will ensure that CTs and wiring are correct and complete.

NOTE

Cycle power to SPM to clear lockout times that may occur during testing.

After testing is complete it is a good idea to zero all statistics.

The following equipment is recommended to test the SPM's functionality and calibration.

1. 3 phase variable ac test set (voltage and current)
2. 0 to 15 V DC voltage source (needed to test Exciter/Field volts or current inputs)
3. Function generator (needed to test collector ring field application)
4. Timer
5. Multimeters
6. Switch

10.2.1 SETUP

1. Connect the Va and Vb terminals of the 3-phase tester to SPM terminals B9 and B10 (control power and PF voltage reference) respectively. Program for 120 V AC.
2. Connect the Switch to terminals A11 and A12 of the SPM (MX input). Close switch.
3. Connect the function generator's output (AC sinewave 5 to 10 V) to the VF terminals A18 and A19. Set to 60 Hz.
4. Connect multimeters to TRIP, FAR and FCX relay outputs to monitor relay status. Note: a timer may be hooked up to start on FAR relay closure and stop on FCX closure to check timing.

10.2.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for following exceptions

- **MOTOR**: Collr-Ring

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.2.3 TEST

1. Apply control power to relay and wait for self-test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Set function generator to 60 Hz and turn on.
3. Open MX switch
4. Lower frequency to 5 Hz: Relay should not apply field.
5. Lower frequency to just under 3 Hz (5% of 60 Hz). FAR contact should close followed by FCX contact 1 second later. FIELD IS APPLIED message should momentarily flash on screen.

Table 10–1: COLLECTOR-RING MOTOR FIELD TEST RESULTS

SETPOINTS		INPUT/EXPECTED		RESULTS	
SLIP	FCX TIME	FREQUENCY	FAR OPERATION	FAR OPERATION	FCX TIME
5%	1	5 Hz	open		
5%	1	3 Hz	close		
10%	5	10 Hz	open		
10%	5	6 Hz	close		

10.3.1 SETUP

1. Connect the Va and Vb terminals of the 3-phase tester to SPM terminals B9 and B10 (control power and PF voltage reference) respectively. Program for 120 V AC. To test the OPTIONAL PF REFERENCE input connect Va and Vb to terminals A4 and A5 and 120 V AC to B9 and B10.
2. Connect Ic of the 3-phase tester terminals B3 and B4. Polarity is critical. Note: Ia and Ib outputs of 3q tester may have to be shorted if they cannot be turned off. Program for 4A.
3. Connect the function generator's output (AC sinewave 5 to 10 V) to the VF terminals A18 and A19. Set to 3 Hz.
4. Connect the Switch to terminals A11 and A12 of the SPM (MX input). Close switch.
5. Connect multimeter to TRIP relay outputs to monitor relay status.

10.3.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for following exceptions

- **MOTOR**: Collector-Ring
- **PF REF**: External (if testing the external PF volt-age reference)

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.3.3 TEST

1. Apply control power to relay and wait for self-test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source and function generator.
3. Open MX switch
4. FAR contact should close followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. PF metered value will now be displayed along with other metered values.
6. Vary voltage angle as in table below and check PF reading.

Table 10–2: COLLECTOR-RING MOTOR PF TEST RESULTS

ANGLE	EXPECTED PF	ACTUAL PF
0°	1	
25°	0.9	
65°	0.4	
317°	–0.74	
341°	–0.95	

10.4.1 SETUP

1. Connect as for Collector-Ring Power Factor Test in the previous section.
2. Connect timer to TRIP relay.

10.4.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for following exceptions

- **MOTOR**: Collector-Ring

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.4.3 TEST

1. Apply control power to relay and wait for self test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source and function generator.
3. Open MX switch
4. FAR contact should close followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. PF metered value will now be displayed along with other metered values.
6. Vary voltage angle as in table below and check PF reading.

Table 10–3: COLLECTOR-RING MOTOR PF TRIP TEST RESULTS

SETPOINTS		INPUT/EXPECTED		RESULTS
PF TRIP	PF DELAY	ANGLE	EXPECTED PF	TRIP TIME
–0.60	1	302°	–0.52	
–0.70	5	309°	–0.63	
–0.80	3	317°	–0.74	
1.00	10	341°	–0.95	

10.5.1 SETUP

1. Connect the Va and Vb terminals of the 3-phase voltage source to SPM terminals B9 and B10 (control power and PF voltage reference) respectively. Program for 120 V AC.
2. Connect the Switch to terminals A11 and A12 of the SPM (MX input). Close switch.
3. Connect multimeters to TRIP and FCX relay outputs to monitor relay status.
4. Connect a timer to start on MX switch opening and stop on FAR closure to check timing. Repeat with FAR and FCX respectively for FCX timing.

10.5.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12.

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.5.3 TEST

1. Apply control power to relay and wait for self-test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Open MX switch
3. FAR contact should close after FAR DELAY expires followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.

Table 10–4: BRUSHLESS MOTOR FIELD APPLICATION TEST RESULTS

SETPOINTS		RESULTS	
FAR DELAY	FCX DELAY	FAR OPERATION	FCX OPERATION
0	1		
10	5		
60	10		

10.6.1 SETUP

1. Connect the Va and Vb terminals of the 3-phase tester to SPM terminals B9 and B10 (control power and PF voltage reference) respectively. Program for 120 V AC. To test the OPTIONAL PF REFERENCE input connect Va and Vb to terminals A4 and A5 and 120VAC to B9 and B10.
2. Connect Ia of the 3-phase tester terminals B3 and B4 and Ib to terminals B1 and B2. Polarity is critical. Note: Ic outputs of 3-phase tester may have to be shorted if they cannot be turned off. Program for 4 A.
3. Connect the Switch to terminals A11 and A12 of the SPM (MX input). Close switch.
4. Connect multimeter to TRIP relay outputs to monitor relay status.

10.6.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for the following:

- **PF REF**: External (if testing the external PF voltage reference)

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.6.3 TEST

1. Apply control power to relay and wait for self-test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source.
3. Open MX switch
4. FAR contact should close after programmed delay followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. PF metered value will now be displayed along with other metered values.
6. Vary voltage angle as in table below and check PF reading.

Table 10–5: BRUSHLESS MOTOR PF TEST RESULTS

ANGLE	EXPECTED PF	ACTUAL PF
0°	1	
25°	0.9	
65°	0.4	
317°	–0.74	
341°	–0.95	

10.7.1 SETUP

1. Connect as for Brushless Motor Power Factor Test in the previous section.
2. Connect timer to TRIP relay.

10.7.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12.

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.7.3 TEST

1. Apply control power to relay and wait for self test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source.
3. Open MX switch
4. FAR contact should close followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. PF metered value will now be displayed along with other metered values.
6. Vary voltage angle as in table below and check PF reading.

Table 10–6: BRUSHLESS MOTOR PF TRIP TEST RESULTS

SETPOINTS		INPUT/EXPECTED		RESULTS
PF TRIP	PF DELAY	ANGLE	EXPECTED PF	TRIP TIME
–0.60	1	302°	–0.52	
–0.70	5	309°	–0.63	
–0.80	3	317°	–0.74	
1.00	10	341°	–0.95	

10.8.1 SETUP

1. Connect as for Collector Ring or Brushless PF Test.

10.8.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for the following:

- **MOTOR**: Collr-Ring (if testing for Collector-Ring application)

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2 except for the following:

- **FL AMPS**: 50

10.8.3 TEST

1. Apply control power to relay and wait for self test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source (and function generator for Collector-Ring).
3. Open MX switch
4. FAR contact should close followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. AC Amps metered value will now be displayed along with other metered values.
6. Vary current as in table below and record reading.
7. At greater than 4x motor full load a pull out trip should occur.

Table 10–7: AC CURRENT METERING AND PULL-OUT RESULTS

INPUT AMPS	EXPECTED READING	ACTUAL READING	TOLERANCE (AC AMPS)
1	10		±1
3	30		±1
5	50		±1
10	100		±3
25	PULL-OUT TRIP		N/A

10.9.1 SETUP

1. Connect as in Section 10.3: COLLECTOR-RING MOTOR POWER FACTOR TEST on page 10–3 or Section 10.6: BRUSHLESS MOTOR POWER FACTOR TEST on page 10–6.
2. Connect DC Voltage source to terminals A20 and A21 (ensure correct polarity).

10.9.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for the following:

- **MOTOR**: Collector-Ring (if testing for Collector-Ring application)

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.9.3 TEST

1. Apply control power to relay and wait for self-test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source (and function generator for Collector-Ring).
3. Open MX switch
4. FAR contact should close followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. DC VOLTS metered value will now be displayed along with other metered values.
6. Vary DC voltage as in table below and record reading.

Table 10–8: EXCITER/FIELD VOLTAGE METERING RESULTS

INPUT DC VOLTS	EXPECTED READING	ACTUAL READING	TOLERANCE (V DC)
0.516	16		±1
1.129	35		±1
3.871	120		±2
6.450	200		±2
10.97	340		±4

10.10.1 SETUP

1. Connect as in Section 10.3: COLLECTOR-RING MOTOR POWER FACTOR TEST on page 10–3 or Section 10.6: BRUSHLESS MOTOR POWER FACTOR TEST on page 10–6.
2. Connect DC Voltage source to terminals A24 and A25 (ensure correct polarity).
3. Note this test is done as secondary injection testing without the CM or DCCT.

10.10.2 RELAY PROGRAMMING

a) CONFIGURATIONS

Program as defaults shown in Section 5.4: CONFIGURATIONS MENU on page 5–12 except for the following:

- **MOTOR**: Collector-Ring (if testing for Collector-Ring application)

b) SETPOINTS

Program as defaults shown in 5.2: SETPOINTS MENU on page 5–2.

10.10.3 TEST

1. Apply control power to relay and wait for self-test diagnostic to complete. Should get SPM READY message and TRIP relay should close.
2. Turn on current source (and function generator for Collector-Ring).
3. Open MX switch
4. FAR contact should close followed by FCX contact. FIELD IS APPLIED message should momentarily flash on screen.
5. DC AMPS metered value will now be displayed along with other metered values.
6. Vary DC voltage as in table below and record reading.

Table 10–9: EXCITER/FIELD CURRENT METERING RESULTS

INPUT DC VOLTS	EXPECTED READING	ACTUAL READING	TOLERANCE (A DC)
0.157	0.5 A		±.0.1 A
0.471	1.5 A		±.0.1 A
0.942	3 A		±.0.1 A
1.256	4 A		±.0.1 A
1.570	5 A		±.0.1 A

DESCRIPTION	DEFAULT	USER VALUE
SETPOINTS		
PF TRIP	–0.60	
PF DELAY	1.0 s	
PF SUPP	6% FLC	
PF MODE	ridethru	
FAR DELAY	0 s	
FCX DELAY	1 s	
AC CT RTG	50/5	
FL AMPS	25	
LR AMPS	200	
SYNC SLIP	5.0%	
STALL TIME	10 s	
RUNTIME	1.05 x ST	
DC CT PRIM	5 A	
HIGH FIELD	OFF	
FIELD AMPS	OFF	
FLD IE DLY	N/A	
FIELD VOLTS	OFF	
EX VLT DELAY	N/A	
INC SEQ DLY	OFF	
REG PF	0.00	
REG GAIN	1	
STABILITY	1 cyc	
REG OUTPUT	1 V	
FLOOR VOLTS	0.0	

DESCRIPTION	DEFAULT	USER VALUE
CONFIGURATIONS		
MOTOR	Coll-Ring	
LINE FREQ	60 Hz	
PF REF	internal	
RTU ADDRESS	1	
BAUD RATE	19.2k	
PARITY	None	
TURNAROUND	5	
STAT	read only	
PASSWORD	0000	
CALIBRATION		
FS EXC VOLT		
FS EXC AMPS		
FS MTR AMPS		

DESCRIPTION	DEFAULT	USER VALUE
SETPOINTS		
PF TRIP	–0.60	
PF DELAY	1.0 s	
PF SUPP	6% FLC	
PF MODE	ridethru	
FAR DELAY	0 s	
FCX DELAY	1 s	
AC CT RTG	50/5	
FL AMPS	25	
LR AMPS	200	
SYNC SLIP	5.0%	
STALL TIME	10 s	
RUNTIME	1.05 x ST	
DC CT PRIM	5 A	
HI EXC FIELD	OFF	
EX FLD AMPS	OFF	
FLD IE DLY	N/A	
EX FLD VOLTS	OFF	
EX VLT DELAY	N/A	
INC SEQ DLY	OFF	
REG PF	0.00	
REG GAIN	1	
STABILITY	1 cyc	
REG OUTPUT	1 V	
FLOOR VOLTS	0.0	

DESCRIPTION	DEFAULT	USER VALUE
CONFIGURATIONS		
MOTOR	Coll-Ring	
LINE FREQ	60 Hz	
PF REF	internal	
RTU ADDRESS	1	
BAUD RATE	19.2k	
PARITY	None	
TURNAROUND	5	
STAT	read only	
PASSWORD	0000	
CALIBRATION		
FS EXC VOLT		
FS EXC AMPS		
FS MTR AMPS		

B

GE MULTILIN RELAY WARRANTY

General Electric Multilin Inc. (GE Multilin) warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorized factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

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GE POWER MANAGEMENT WEBSITE

The latest product information for the SPM Synchronous Motor Protection and Control relay is available on the Internet via the GE Multilin home page:

http://www.GEmultilin.com

Click here for viewers download page.

This site provides access to the following customer services:

- Digital Products Directory
  A brief description of products can be viewed online.
- Product Catalog
  Individual product brochures can be downloaded and printed
- Product Selector Guide
  A graphical tool for finding the product you are interested in
- Sales Offices
  A complete listing of world-wide sales offices
- Technical Support
  Complete contact information is available
- Instruction Manuals
  Manuals for many products are now available online
- GE Product Software
  The latest working versions of product software
- Technical Drawings
  Many technical drawings are available in either AutoCAD, CorelDRAW, or PDF formats.
- Order Codes
  Order codes for many products can be downloaded and printed
- Technical Publications
  Papers related to power management

Much more is also available. Visit us online at: **www.GEmultilin.com**